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The Boom of Coeliac Disease Diagnoses and Its Impact on the Italian Restaurant Industry

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Abstract

About thirty years ago, a coeliac disease diagnosis was a real burden. The disease was not well known and researched, and it was, thus, shrouded in a considerable degree of uncertainty. The products that were specifically realized for individuals suffering from the condition were very few, exclusively purchasable in pharmacies, mostly tasteless, and sold at incredibly high prices. People affected by coeliac disease were doomed to say their farewells to freshly baked bread and pastries and finding a suitable restaurant to eat out at was unconceivable. Traveling was also an issue, as patients were forced to fill their suitcases with their own packaged food. Coeliac disease was not only a dietary disease, but also a psychological disease, as it used to drastically impact the social life of the individuals and, hence, decrease their overall life quality.

Nowadays, the situation is radically different. Coeliac disease is not considered a rare disease anymore and the number of diagnoses has substantially grown overtime. There is now widespread awareness of the condition and gluten free products are not as hard to spot on the market as they used to be. The major driver of this change is, doubtlessly, the rising prevalence of the disease among the population. A relevant role, however, is also played by the increasing attention towards healthy eating and by the increasing concern on food allergies and intolerances.

As the number of individuals with specific dietary needs, especially gluten-related, is rapidly increasing, many restaurants have taken the decision to expand their offer by introducing gluten free products on their menus. Can the entry on the market of such products be predicted by the dimension of the coeliac market? Focusing on the Italian restaurant industry, I will use a regression model whose main independent variable is the number of people affected by coeliac disease in order to try and answer this question.

Introduction

In 2018, the global prevalence of coeliac disease was estimated to be 1.4% (Singh et al., 2018). It is, in fact, not considered a rare condition anymore. The number of diagnoses is growing at a staggering pace and the gluten free market is predicted to expand exponentially. If about thirty years ago many people did not have a clue of what gluten was, it is now on everyone's lips. Reading the 'gluten free' claim became so frequent that consumers even shifted their perception of a gluten free diet as a healthier alternative. The public is getting more and more attentive when it comes to choosing what is going to be put on the table, whether for lifestyle or health reasons, and food is turning into a trendy obsession. The rising awareness on specific dietary requests led the restaurant industry to adapt accordingly, so as to satisfy the changing demand. The world is today a more accommodating place for people suffering from food allergies, intolerances, or serious conditions like coeliac disease. It is not uncommon anymore to find on restaurant menus 'free from' claims and a list of allergens beside the description of each dish.

In Italy, 233,147 individuals were diagnosed with coeliac disease in 2020 and the estimated prevalence of the disease on the Italian territory is 1% (Italian Ministry of Health, 2022). The Italian restaurant industry as well is, consequently, transforming in order to fulfill the needs of the Italian consumers. How is it actually transforming, though? Specifically, this analysis will make use of a regression model for the purpose of explaining the relationship between the number of restaurants providing gluten free meals and the number of people with coeliac disease. The study has the objective to determine how the growth in the number of coeliac disease diagnoses in effect translates on the Italian market by studying the potential drivers inducing restaurants to expand their offer and provide gluten free options.

As in 2016 I was diagnosed with coeliac disease, I am part of the 1% of Italian population affected by such illness. This phenomenon is, therefore, particularly dear to me. Experiencing firsthand what it means to be needing to follow a gluten free diet in Italy in 2022, I am personally concerned by the issue and this research was born out of my curiosity to deeply understand the Italian gluten free market and the factors influencing it.

In the first chapter, an overview on coeliac disease is provided and the differences among coeliac disease, gluten allergy and gluten sensitivity are explained. The numbers pertaining to the diffusion of the condition, both globally and in Italy, are analyzed. Then, the focus shifts on how coeliac disease is handled in Italy. Lastly, the gluten free market is examined.

The second chapter represents the core of my study: the econometric analysis. Firstly, the data and its sources are presented; then, the regression model is introduced, and the results of the regression are displayed and discussed.

Coeliac Disease

What is Coeliac Disease?

Coeliac disease is an autoimmune disease that occurs in genetically predisposed individuals. It is triggered by the ingestion of gluten, which is the protein component of wheat, rye, and barley. Exposure to gluten in individuals affected by coeliac disease results in a variable degree of intestinal damage (Ludvigsson et al., 2013).

In the past, coeliac disease was considered a childhood gastrointestinal disease; it is now recognized as a disease that may affect people of any age, gender, and ethnicity. Such disease may be developed at any moment in the life of an individual. Recurring signs and symptoms comprehend chronic diarrhea, abdominal pain, weight loss, and abdominal distention, but also iron deficiency (with or without anemia), chronic fatigue, and short stature (Fasano and Catassi, 2012). The major issue in the diagnosis of the disease is that gastrointestinal symptoms may be even totally absent, and patients may exclusively show extraintestinal complications (Mustalahti et al., 2010). Celiac disease is a lifelong disease, and the only treatment is to follow a restrictive gluten free diet. For most patients, this will cure current intestinal damage and prevent further harm. If the patient does not adhere to the gluten free diet, complications may arise. The sprectrum of complications is very broad and it includes acute malabsorption leading to anemia, somatic and psychosocial retardation, impairment of life quality, infertility, miscarriage, preterm birth, low birth weight, osteoporosis, extraintestinal manifestations (e.g. neurological, renal, pulmonary), autoimmune diseases, cancer, and increased mortality (Schuppan et al., 2013).

Gluten-related disorders are not only limited to celiac disease. Among these disorders, we find wheat allergy, a different type of adverse immunologic reaction to proteins contained in wheat and related grains. Wheat allergy is divided into occupational asthma and rhinitis, food allergy affecting skin, gastrointestinal tract or respiratory tract, and wheat-dependent exercise-induced anaphylaxis and contact urticaria (Elli et al., 2015). Wheat allergy is particularly common in children, who typically outgrow it by school-age. In adults, food allergy to ingested wheat is less frequent: the most common

variant is the wheat-dependent exercise-induced anaphylaxis. A wheat free diet is not as limited as a strict gluten free diet, as most patients with wheat allergy are usually allowed to eat rye, barley, and oats. Differently from coeliac disease, wheat allergy does not cause permanent gastrointestinal or other organ damage once the acute reaction has passed (Pietzak and Kerner, 2012).

When the removal of gluten from the diet results in symptomatic improvement in a patient having neither celiac disease nor wheat allergy, the patient is labeled as "gluten sensitive". The gastrointestinal symptoms can be hard to distinguish between these three conditions. However, differently from celiac disease and wheat allergy, gluten sensitivity is not related to any allergy process and its gastrointestinal manifestations do not cause permanent damage (Pietzak and Kerner, 2012).

Even though the three conditions are all treated similarly, with the removal of gluten or wheat, it is important to differentiate among them. This is because coeliac disease is the only among the three leading to the development of other autoimmune conditions, nutrition deficiencies, higher risk for cancer, and increased mortality (Pietzak and Kerner, 2012), thus, individuals suffering from coeliac disease, unlike individuals suffering from wheat allergy or gluten sensitivity, need to be frequently monitored. According to a recent Markov-model analysis, in fact, mass screening for celiac disease of the population would result in improved quality-adjusted life years (QALY) and would be a cost-effective strategy as long as the time delay to diagnosis exceeds six years (Mustalahti et al., 2010).

Gluten Free in Numbers

Many studies have been conducted with the aim to investigate the actual prevalence of coeliac disease in the world. In Europe, a mass screening project involving four different countries (Finland, Italy, Germany, and UK) and 29,212 individuals demonstrated that the overall coeliac disease frequency among European countries is 1%, with the 95% confidence interval being 0.9 - 1.1. Moreover, the study highlighted a large inter-country variability, probably due to genetic and environmental factors, with Finland being the country with the highest prevalence (2.4%) and Germany the country with the lowest prevalence (0.3%). The findings not only confirmed that coeliac disease is one of the most common permanent disorders in Europe, but also shed light on how highly underdiagnosed it is in all countries, even in those with a high knowledge of the disease (Mustalahti et al., 2010).

Similar prevalence rates have been observed in the US (0.7%) and in other developed countries inhabited by individuals of European provenance, such as Australia (0.4%), and New Zealand (1.1%). Also, many South American countries present high rates of prevalence (Lionetti et al., 2015). In 2018, in order to estimate the exact global prevalence of coeliac disease, a systematic review and meta-

analysis was conducted. The results concluded that the global prevalence of the disease was 1.4%. (Sinch et al., 2018). Prevalence was observed to vary with sex, age, and location.

The overall number of celiac disease diagnoses has increased in the recent past. In order to determine whether the higher number of diagnoses implies an actual rise in disease frequency, research was carried out. The coeliac disease prevalence rate was detected in two cross-sectional population cohorts representing the Finnish adult population at two distinct points in time, the first one being 1978-1980, and the second being 2000-2001. The results of the study showed that total prevalence of the disease nearly doubled in two decades, with a statistically significant increase from 1.05% to 1.99% (Lohi et al., 2007).

In Italy, according to the data disclosed in the Relazione Annuale al Parlamento sulla Celiachia 2020 (Annual Coeliac Disease Report to the Parliament 2020), coeliac disease affects approximately 1% of the population (Italian Ministry of Health, 2022). The number of individuals diagnosed with such chronic illness is 233,147, of which 30% males and 70% females; about 400,000 individuals represent the hidden part of the "coeliac disease iceberg". The regions registering the highest number of individuals affected by coeliac disease are Lombardia (42,440), Lazio (23,633), and Campania (22,542).

Region	***Celiacs 2020***	***Males***	***Females***	***M:F***
Abruzzo	5,527	1,598	3,929	2
Basilicata	1,710	483	1,227	3
Calabria	6,422	1,794	4,628	3
Campania	22,542	7,279	15,263	2
Emilia Romagna	18,807	5,887	12,920	2
Friuli Venezia Giulia	4,122	1,198	2,924	2
Lazio	23,633	6,916	16,717	2
Liguria	5,759	1,704	4,055	2
Lombardia	42,440	13,049	29,391	2
Marche	4,789	1,474	3,315	2
Molise	1,042	270	772	3
Piemonte	15,470	4,393	11,077	3
Puglia	13,931	4,178	9,753	2
Sardegna	7,593	2,092	5,501	3
Sicilia	17,082	5,337	11,745	2
Toscana	17,932	5,211	12,721	2
Trentino Alto Adige	4,575	1,430	3,145	2
Umbria	3,821	1,141	2,680	2
Valle d'Aosta	605	196	409	2
Veneto	15,345	4,634	10,711	2
TOTAL	233,147	70,264	162,883	2

Figure 1 (Italian Ministry of Health, 2022)

Figure 1 highlights the fact that coeliac disease is more frequent in females rather than males. Figure 2 below, instead, aims to display the incidence of the disease on the Italian population.

Region	***Italian Population****	***Celiacs 2020***	***Incidence (%)***
Abruzzo	1,285,256	5,527	0.43
Basilicata	547,579	1,710	0.31
Calabria	1,877,728	6,422	0.34
Campania	5,679,759	22,542	0.4
Emilia Romagna	4,445,549	18,807	0.42
Friuli Venezia Giulia	1,198,753	4,122	0.34
Lazio	5,720,796	23,633	0.41
Liguria	1,509,805	5,759	0.38
Lombardia	9,966,992	42,440	0.43
Marche	1,501,406	4,789	0.32
Molise	296,547	1,042	0.35
Piemonte	4,273,210	15,470	0.36
Puglia	3,926,931	13,931	0.35
Sardegna	1,598,225	7,593	0.48
Sicilia	4,840,876	17,082	0.35
Toscana	3,668,333	17,932	0.49
Trentino Alto Adige	1,078,460	4,575	0.42
Umbria	865,013	3,821	0.44
Valle d'Aosta	123,895	605	0.49
Veneto	4,852,453	15,345	0.32
TOTAL	59,257,566	233,147	0.39

*Istat data updated on 01/01/2021

Figure 2 (Italian Ministry of Health, 2022)

Region	***Male Population****	***Female Population****	***Incidence M (%)***	***Incidence F (%)***
Abruzzo	627,509	657,747	0.25	0.6
Basilicata	269,350	278,229	0.18	0.44
Calabria	919,061	958,667	0.20	0.48
Campania	2,767,607	2,912,152	0.26	0.52
Emilia Romagna	2,165,612	2,279,937	0.27	0.57
Friuli Venezia Giulia	583,280	615,473	0.21	0.48
Lazio	2,761,729	2,959,067	0.25	0.56
Liguria	723,647	786,158	0.24	0.52
Lombardia	4,882,206	5,084,786	0.27	0.58
Marche	730,536	770,870	0.20	0.43
Molise	145,946	150,601	0.18	0.51
Piemonte	2,077,405	2,195,805	0.21	0.50
Puglia	1,910,616	2,016,315	0.22	0.48
Sardegna	784,501	813,724	0.27	0.68

Sicilia	2,353,823	2,487,053	0.23	0.47
Toscana	1,773,215	1,895,118	0.29	0.67
Trentino Alto Adige	531,999	546,461	0.27	0.58
Umbria	417,598	447,415	0.27	0.6
Valle d'Aosta	60,557	63,338	0.32	0.65
Veneto	2,377,891	2,474,562	0.19	0.43
TOTAL	28,864,088	30,393,478	0.24	0.54

* Istat data updated on 01/01/2021

Figure 3 (Italian Ministry of Health, 2022)

In the third table, a distinction is made between incidence on the male and on the female population, while Figure 4 presents the prevalence of coeliac disease over the years 2018, 2019, and 2020.

Region	***Incidence 2018 (%)***	***Incidence 2019 (%)***	***Incidence 2020 (%)***
Abruzzo	0.38	0.4	0.43
Basilicata	0.25	0.3	0.31
Calabria	0.34	0.35	0.34
Campania	0.36	0.39	0.4
Emilia Romagna	0.4	0.41	0.42
Friuli Venezia Giulia	0.32	0.33	0.34
Lazio	0.36	0.38	0.41
Liguria	0.34	0.36	0.38
Lombardia	0.38	0.4	0.43
Marche	0.31	0.3	0.32
Molise	0.32	0.34	0.35
Piemonte	0.34	0.34	0.36
Puglia	0.32	0.34	0.35
Sardegna	0.44	0.45	0.48
Sicilia	0.28	0.35	0.35
Toscana	0.45	0.46	0.49
Trentino Alto Adige	0.39	0.41	0.42
Umbria	0.41	0.42	0.44
Valle d'Aosta	0.44	0.46	0.49
Veneto	0.28	0.30	0.32
TOTAL	0.35	0.37	0.39

Figure 4 (Italian Ministry of Health, 2022)

On average, each year 8,680 new cases are diagnosed (Italian Ministry of Health, 2022). Figure 5 exhibits the increase in diagnoses from 2014 to 2020. It is immediate to notice the substantial rise in the number of cases; in the time span considered, 60,950 new diagnoses were observed.

Region	***Celiacs 2014***	***Celiacs 2015***	***Celiacs 2016***	***Celiacs 2017***	***Celiacs 2018***	***Celiacs 2019***	***Celiacs 2020***
Abruzzo	4,139	4,611	4,875	5,071	4,960	5,255	5,527
Basilicata	983	1,012	1,461	1,318	1,395	1,670	1,710
Calabria	5,122	5,333	5,885	6,472	6,685	6,738	6,422
Campania	15,509	17,777	18,720	19,673	20,735	22,320	22,542
Emilia Romagna	14,000	14,803	16,020	16,765	17,999	18,239	18,807
Friuli Venezia Giulia	3,207	3,210	3,411	3,603	3,928	3,952	4,122
Lazio	17,355	17,777	19,325	21,063	21,020	22,157	23,633
Liguria	4,428	4,769	4,953	5,200	5,316	5,549	5,759
Lombardia	30,541	32,408	37,907	36,529	38,420	40,317	42,440
Marche	3,179	3,381	3,460	4,528	4,716	4,569	4,789
Molise	853	898	910	943	999	1,024	1,042
Piemonte	11,732	12,361	13,153	13,784	15,017	14,878	15,470
Puglia	10,531	11,494	11,866	12,485	12,853	13,596	13,931
Sardegna	6,145	6,107	6,783	7,290	7,293	7,383	7,593
Sicilia	13,376	14,199	14,880	15,252	14,022	17,260	17,082
Toscana	14,066	14,357	15,351	15,799	16,684	17,177	17,932
Trentino Alto Adige	3,186	3,378	3,628	3,864	4,115	4,365	4,575
Umbria	2,588	2,972	3,025	3,428	3,617	3,707	3,821
Valle d'Aosta	444	467	500	520	558	583	605
Veneto	10,813	11,544	12,314	12,974	13,907	14,679	15,345
TOTAL	172,197	182,858	198,427	206,561	214,239	225,418	233,147

Figure 5 (Italian Ministry of Health, 2022)

Coealiac Disease in Italy

In 1979 the AIC - Associazione Italiana Celiachia (Italian Coeliac Disease Association) was established on the initiative of some parents of children affected by coeliac disease. At the time the disease was not very well known, and it was still merely considered a pediatric disease; assistance was absent, and patients were left with no guidance. Hence, the association was founded to raise awareness on the disease and to fulfill the need for support by creating a community of families facing the same issues. AIC is one of the founding members of AOECS (Association of European Coeliac Societies). Nowadays, AIC is a well-established association which endorses the health and the social rights of the individuals affected by coeliac disease; it also fosters scientific research through Fondazione Celiachia (FC). Since 2005 coeliac disease has been recognized as "social disease", as food has a major role in the lives of individuals, especially in the Italian culture. The diagnosis impacts

almost all contexts and aspects of life and can, consequently, be tough to accept or handle. Therefore, AIC offers, among its services, also the possibility to receive psychological support and to attend self-help groups. The ultimate goal of the association is to improve from all perspectives the quality of life of people suffering from coeliac disease.

The "ABC of the Gluten Free Diet", available on the AIC website, provides a detailed classification of safe and forbidden foods and drinks and it represents the most important guide for all individuals following a gluten-restricted diet. The "Spiga Barrata" ("Crossed grain") trademark is the symbol of AIC: it guides people in choosing safe and guaranteed food and it also allows for immediate recognition of such products. The logo is only granted to packaged products; firms wanting to apply the "Spiga Barrata" label are required to undergo AIC's annual auditing and inspection of plants and production processes: specific production, management, and control requisites are to be met in order to guarantee a gluten content lower than 20 ppm. More than 170 production plants were audited by AIC in 2021, and in the last ten years the number of guaranteed products grew by 160%. The trademark was registered in the 1990s; currently, thanks to the collaboration among European Coeliac Societies coordinated by AOECS (Association of European Coeliac Societies), it is widely regarded as a gluten free "gold standard" throughout Europe.

Since the gluten free products that are specifically produced for people suffering from coeliac disease are more expensive and sometimes difficult to access, the Italian National Health Service provides assistance to the individuals diagnosed with the disease by providing them a monthly allowance to be spent on such products. The amount offered depends on the age group and on the gender of the individual, and it is computed in such a way that allows the individual to follow a varied and balanced diet and to meet his or her ideal energy intake. Since the advised daily energy intake should be constituted by at least 55% of carbohydrates, of which 20% naturally gluten free, the allowance is meant to cover the remaining 35%.

Age	***Males***	***Females***
6 months - 5	€ 56	€ 56
6 – 9	€ 70	€ 70
10 – 13	€ 100	€ 90
14 – 17	€ 124	€ 99
18 – 59	€ 110	€ 90
≥ 60	€ 89	€75

Figure 6 (Italian Ministry of Health, 2022)

Spending limits were updated in 2018, based on Recommended Energy and Nutrient Intake Levels for the Italian population (2014) and on recorded consumer prices in the pharmaceutical channel increased by 30% to take into account particular nutritional needs.
According to the collected data, in 2020 the Italian National Health Service spent € 209,688,912.20 for the purchase of gluten free products, with an average per capita expenditure of about €1,000. The regional expenditure is reported in Figure 7.

Region	***Regional Expenditure 2020***	***Celiacs 2020***	***Average per capita expenditure***
Abruzzo	€ 5,782,509.97	5,527	€ 1,046.23
Basilicata	€ 1,791,813.99	1,710	€ 1,047.84
Calabria	€ 7,010,415.25	6,422	€ 1,091.62
Campania	€ 22,895,514.60	22,542	€1,015.68
Emilia Romagna	€ 19,352,570.22	18,807	€ 1,029.01
Friuli Venezia Giulia	€3,888,759.00	4,122	€ 943.42
*Lazio**	d.n.r.	23,633	d.n.r.
Liguria	€ 5,790,547.21	5,759	€ 1,005.48
Lombardia	€ 40,728,954.72	42,440	€ 959.68
Marche	€ 3,760,184.41	4,789	€ 785.17
Molise	€ 1,136,993.00	1,042	€ 1,091.16
Piemonte	€ 15,678,707.00	15,470	€ 1,013.49
Puglia	€ 11,742,134.89	13,931	€ 842.88
Sardegna	€ 7,151,499.39	7,593	€ 941,85
Sicilia	€ 20,679,178.16	17,082	€ 1,210.58
Toscana	€ 17,446,006.61	17,932	€ 972.90
Trentino Alto Adige	€ 4,854,510.13	4,575	€ 1,061.1
Umbria	€ 3,742,379.65	3,821	€ 979.42
Valle d'Aosta	€ 652,311.00	605	€ 1,078.20
Veneto	€ 15,603,923.00	15,345	€ 1,016.87
TOTAL	€ 209,688,912.20	233,147	€ 1,009.22

*In 2020 Region Lazio did not provide the data on expenditure

Figure 7 (Italian Ministry of Health, 2022)

Individuals suffering from coeliac disease are, therefore, aided by the government when it comes to eating at home. For what concerns eating outside, AIC's Programma Alimentazione Fuori Casa (AFC) – Eat Out Program – is the benchmark. Adherence is open to any kind of shops which provide food, such as restaurants, bakeries, hotels, and ice cream shops. Being part of the AFC network implies having participated to courses on coeliac disease and on the gluten free diet, having received specific formation, strictly following the set of rules provided by AIC for the preparation of food in order to avoid cross contamination, exclusively using gluten free ingredients, and allowing periodical AIC auditing. Nowadays, the AFC Program counts 4,134 businesses (AIC, 2022). The government's

attempt to protect the citizens suffering from coeliac disease when eating out, instead, is represented by Law 123/2005. The legislation provides specific funds to guarantee the supply, upon request, of gluten free meals in school, hospital, and public canteens, and to implement the formation of food business operators (Italian Ministry of Health, 2022).

Since coeliac disease is a chronic illness which may lead to serious complications, the cost of prevention is much more bearable than the cost of hospitalization and treatment. Based on this reasoning, the Italian Government decided to invest on the diagnostic path and to support the patient in the follow-up of the disease and in the gluten free diet.

The Gluten Free Market

Commission Implementing Regulation (EU) No 828/2014 sets out the requirements for foods to be labelled as 'gluten free' or 'very low gluten'. The statement 'gluten free' may only be made where the food as sold to the final consumer contains no more than 20 mg/kg of gluten. The statement 'very low gluten' may only be made where the food, consisting of or containing one or more ingredients made from wheat, rye, barley, oats, or their crossbred varieties which have been specially processed to reduce the gluten content, contains no more than 100 mg/kg of gluten in the food as sold to the final consumer. Oats represent a special case, as there is an ongoing debate on whether they are gluten free or not. Technically, pure oats are gluten free. Nevertheless, they are often subject to cross contamination, as they are usually processed in the same facilities as other prohibited grains. According to the European Regulation, oats contained in a food presented as 'gluten free' or 'very low gluten' must have been specially produced, prepared, and/or processed in a way to avoid contamination by wheat, rye, barley, or their crossbred varieties and the gluten content of such oats cannot exceed 20 mg/kg.

The recent considerable interest gained by the 'gluten free' label resulted in an increase in the sales of such products, with retail sales in the United States doubling since 2011 (Zysk et al., 2019). In 2020, the global market for gluten free products was valued at USD 5.6 billion (Statista, 2020) and it is expected to expand markedly over the next years. As shown in Figure 8, the market is predicted to grow from USD 5.6 billion in 2020 to USD 8.3 billion in 2025. To better comprehend the phenomenon, the CAGR (compound annual growth rate) of such market from 2018 to 2022 was also computed by segmenting it into product categories. The analyzed categories were pasta, baked goods, ready meals, biscuits, baby food, and breakfast cereal and their respective CAGRs were 12.3%, 10.5%, 8.2%, 7.5%, 7.2%, 5.2% (Agriculture and Agri-Food Canada, 2019).

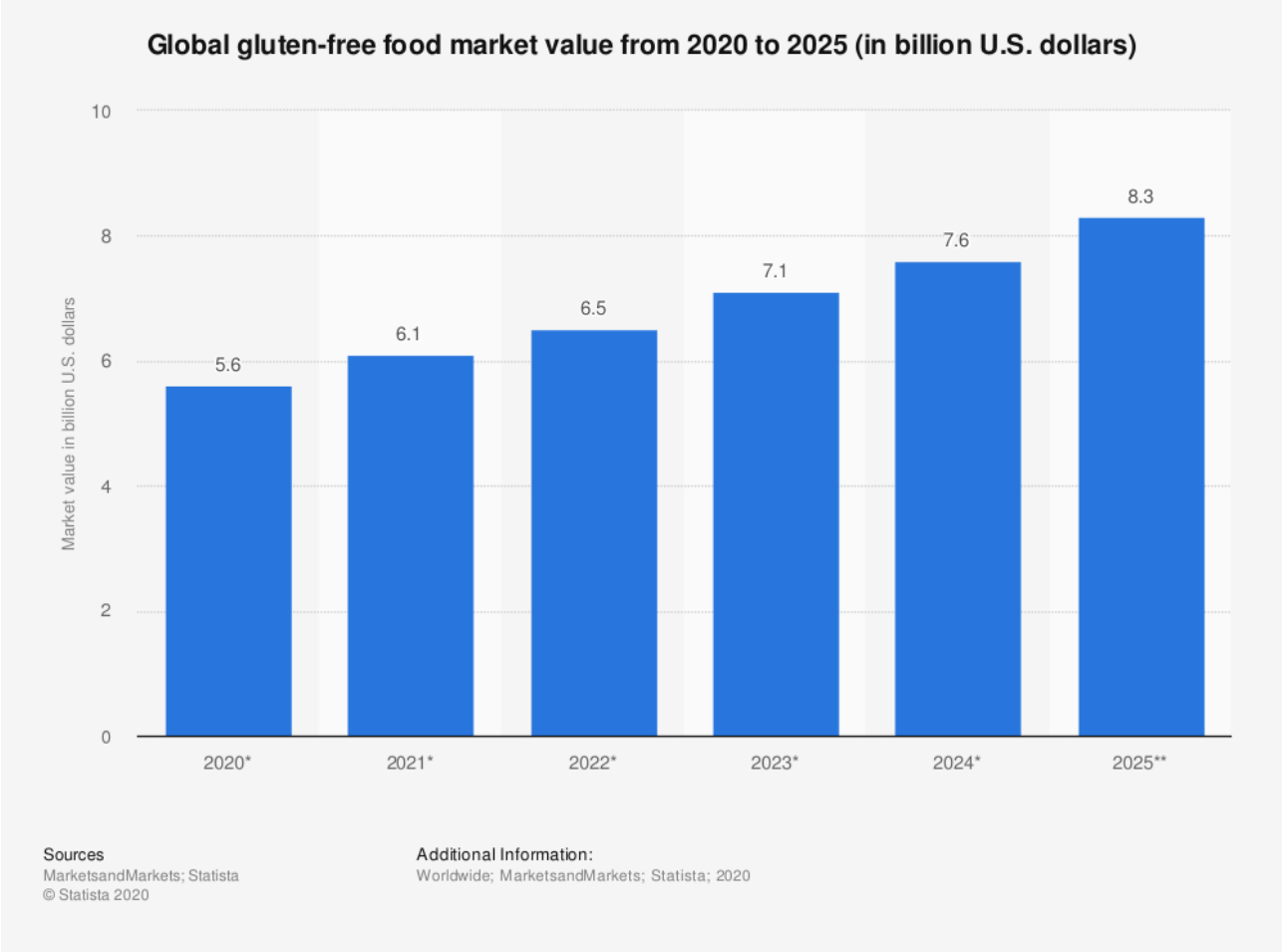

Figure 8 (Statista, 2020)

The major determinant of the astounding expansion of the global gluten free market is certainly the increasing number of coeliac disease diagnoses, complemented by the always wider diffusion of wheat allergy and gluten sensitivity. A significant role is, however, also played by the rising popularity of following a gluten free diet not by necessity, but as a lifestyle choice. Consumer have been shifting their attention towards healthy eating and the increased demand for 'free-from' foods is substantially fueling the gluten free market growth. Lately, common belief has started to associate the 'gluten free' claim to several health benefits, such as weight loss, and improved digestion. The gluten free mania is even extended to cosmetics, in which, nonetheless, the 'gluten free' claim is unjustified. Indeed, people affected by coeliac disease and related disorders are not harmed by gluten-containing makeup products. Many celebrities, books, and magazines joined in praising the avoidance of gluten and, thus, contributed to spread the conviction that gluten free means healthier. Nevertheless, the reality is quite the opposite. Wheat consumption brings various health benefits as it is a valuable source of essential nutrients; it provides carbohydrate-based energy and fiber, protein, B vitamins, calcium, magnesium, phosphorus, potassium, zinc, and iron (Sabença et al., 2021). A study analyzing the nutritional quality of gluten free products, instead, emphasized their inadequacies:

they have less protein and fiber, a higher glycemic index and a higher content of saturated fat, carbohydrate, and salt with respect to their gluten containing counterparts (Myhrstad et al., 2021). Besides, to make their texture more similar to conventional products, additives and thickeners are included. As a result, it is reported that coeliac disease patients tend to actually gain weight when they begin to avoid gluten, and that following a gluten free diet may cause nutrient deficiencies (Sabença et al., 2021).

Despite the evidence, adhering to a gluten free diet is still considered fashionable and healthy. According to the Statista Global Consumer Survey of 2022, in the United States 11% of the population follows a diet that is free from gluten (Statista, 2022). A questionnaire on consumer's motivations for purchasing gluten free bread in the United States disclosed that, out of 1,000 respondents, 31% indicated that they do so as a lifestyle choice and 15% because they deem it easier to digest (Baking Business, 2015).

In Italy the gluten free market is valued at circa € 300 million, with an average annual growth rate of 30% (Osservatorio Agroalimentare, 2016). Italy, as well, is not exempted by the gluten avoidance trend. In 2019, research was carried out to understand the share of Italian consumers buying gluten free food. 19.3% of the respondents stated that they purchase gluten free products, of which only 6.4% reported to do so because diagnosed with an intolerance (EURISPES, 2019). The establishment on the Italian market of gluten free products may be attested by the introduction in 2015 of gluten free pasta and biscuits in the basket used for the calculation of consumer price index. Every year, Istat, the Italian National Institute of Statistics, reviews and updates the list of products composing the market basket that is employed to measure inflation. The debut of the 'gluten free' label in the basket implies that such products have become of regular consumption and can often be found on the tables of Italian families.

Gluten free products exhibit higher prices compared to their gluten containing equivalents. Federconsumatori, an Italian no profit association which aims to inform and protect consumers, investigated in 2016 such price differences. Firstly, it highlighted a significant divergence of prices even among gluten free products: the supermarket prices for gluten free food are significantly lower than the prices for the same products in pharmacies and specialized stores. Then, it inspected the distinction in the prices of restaurant meals between traditional and gluten free food. The outcome of the examination is illustrated in Figure 9.

	Gluten free product price (€)	*Traditional product price (€)*	*Percentage difference*
Bruschette	6	5	20%

Fried mix	10	8.5	18%
First course	13	11	18%
Pizza	9	7.5	20%
Hamburger and fries	9.5	8	19%
Dessert	6	5	20%

Figure 9 (Federconsumatori, 2016)

The higher prices of gluten free products depend on the smaller dimension of the market for gluten free dietary products compared to the market for conventional products. The primary driver of the elevated prices, however, is the complex form of production associated with gluten free products. As previously discussed, a 'gluten free' label may only be applied when the set requirements are met, but satisfying these criteria is not an easy task. Guaranteeing a gluten content within the threshold values entails strict monitoring and precautionary measures that bid up production costs. Likewise, restaurants incur higher prices for gluten free raw materials, and then must account for the costly procedures required to avoid the risk of cross contamination. Ensuring safety and suitability for people suffering from coeliac disease is expensive for producers, which, therefore, need to impose higher prices to make up for it.

The Econometric Analysis

The Data

The aim of my study is to investigate how the recent boom of coeliac disease diagnoses is impacting the Italian restaurant industry. The study stems from my assumption that as the number of people following a gluten free diet rises, the number of restaurants offering gluten free meals should rise as well. The economic rationale backing up my idea is the law of supply and demand. As the quantity of people with the necessity of avoiding gluten augments, a wider set of individuals will consume gluten free products and the demand for coeliac-disease-suitable options will, therefore, increase. An upward shift of the demand curve will translate into a price increase: consumers will be willing to pay a higher price at any given quantity. As prices soar, producers will want to sell more. As a result, total output will increase. Hence, with a higher demand for gluten free food, restaurants will be more inclined to adapt their menus accordingly.

The intent of my analysis is to find whether data confirms my hypothesis or not, by running a regression to test the effect of the increase in diagnoses on the number of coeliac-suitable restaurants.

The data on the number of restaurants offering gluten free products was taken from the AIC (Associazione Italiana Celiachia) website. As these figures only account for the number of restaurants adhering to AIC's Programma Alimentazione Fuori Casa (Eating Out Program), they do not accurately depict the current situation of the Italian restaurant industry. Adherence to the network is voluntary; restaurants may offer gluten free meals but decide not to participate in the AFC Program. AIC certification is a guarantee of safety, but it is up to the individual affected by the disease to choose whether to only eat at certified restaurants or not. However, even though the data on the number of gluten free restaurants might underestimate the actual condition, it is still a good proxy. According to AIC data, the region counting the highest number of suitable restaurants is Toscana (522), followed by Lombardia (458), and Puglia (394). When considering the provinces, instead, Rome places first with 162 certified restaurants, the small province of Perugia is surprisingly second (147), and then comes Florence with a gap of 10 restaurants. As for the least accommodating regions for individuals following a gluten free diet, we find Basilicata (9), Valle d'Aosta (20), and Sardegna (41). The provinces registering the lowest numbers are Oristano, Matera, and Cagliari, respectively counting 2, 3, and 3 certified restaurants (AIC, 2022).

The number of people suffering from coeliac disease was extracted from "Relazione Annuale al Parlamento sulla Celiachia - anno 2020" ("Annual Coeliac Disease Relation to the Parliament - year 2020"), provided by the Italian Ministry of Health. Lombardia (42,440), Lazio (23,633), and Campania (22,542) present the highest number of patients, while the lowest figures are registered in Valle d'Aosta (605), Molise (1042), and Basilicata (1710) (Italian Ministry of Health, 2022). By exclusively considering the quantity of coeliac disease diagnoses, we are, however, overlooking a significant amount of people following a gluten free diet: the figures do not account for individuals who are allergic to wheat or gluten sensitive. Unfortunately, as there are no official measurements of such data, we cannot include them in our regression. Furthermore, an additional group of people who might be prone to seek gluten free options is not contemplated: those individuals who do not need to cut gluten out of their diet, yet, for different reasons, they choose to.

Figure 10 illustrates the correlation between the number of restaurants providing gluten free options and the number of diagnosed individuals. Since the data shows an uphill pattern, the scatterplot suggests a positive relationship between the two variables. The graph is, however, only meant to highlight the statistical trend observed and no causality relationship can be inferred from it: as the number of celiacs increases, the number of gluten free restaurants increases as well, but this does not

imply that the increase in the number of celiacs causes the increase in the number of gluten free restaurants.

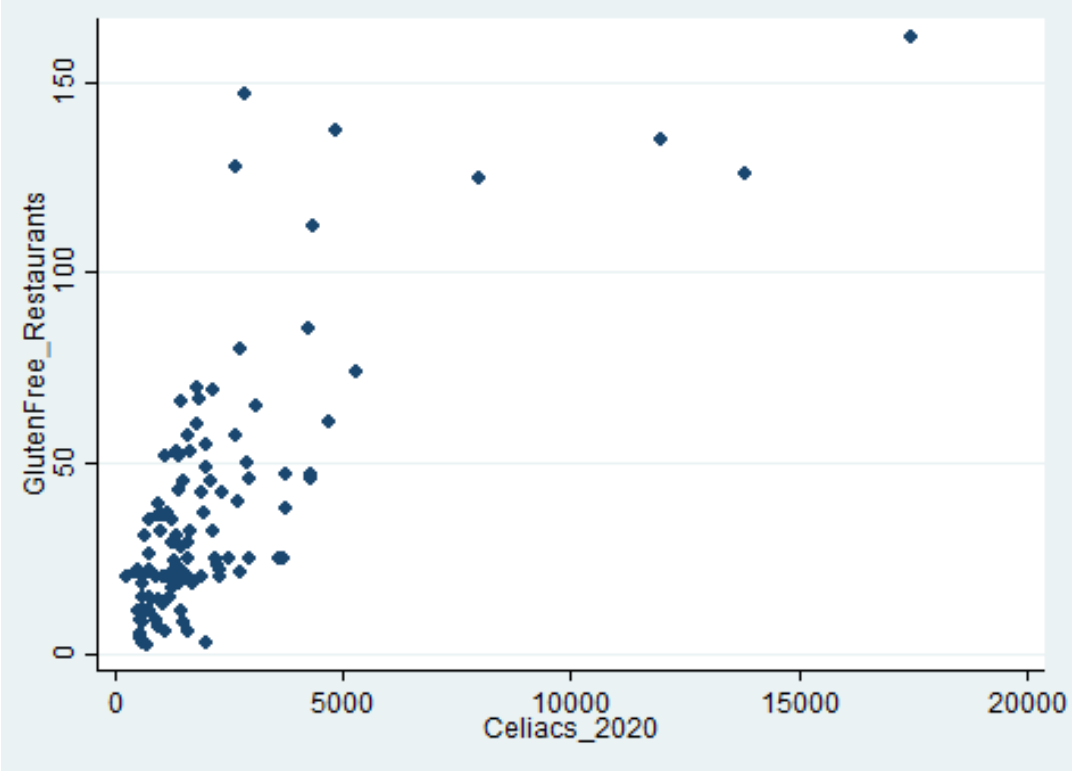

Figure 10 (Generated on Stata on the base of collected data)

The Regression Model

To understand how the boom of coeliac disease diagnoses affects the number of restaurants providing gluten free options to their customers, I ran a linear regression model. The coefficients are estimated through OLS (Ordinary Least Squares), which means that they minimize the sum of squared mistakes (Stock et al., 2015). In a multiple regression, OLS provides an appropriate estimator of the regression coefficients under the following assumptions:

1. The conditional distribution of u_i given X_{1i}, X_{2i}, …, X_{ki} has a mean of zero. This is the key assumption making the OLS estimators unbiased.

2. (X_{1i}, X_{2i}, …, X_{ki}, Yi), i =1, …, n, are independently and identically distributed. If the data is gathered by simple random sampling, this assumption automatically holds.

3. Large outliers are unlikely. This means that it is unlikely to observe values far outside the usual range of data.

4. There is no perfect multicollinearity (i.e., none of the regressors is a perfect linear function of the other regressors).

The regression model is:

$$LogGlutenFree\_Restaurants_i = \beta_0 + \beta_1 LogCeliacs_i + \beta_2 LogInhabitants_i + \beta_3 LogEducation_i + \beta_4 LogTourism_i + \beta_5 LogIncome_i + \beta_6 LogRestaurants_i + \beta_7 LogValue\_Added_i + \beta_8 Organic_i$$

- Log_GlutenFree_Restaurants$_i$ = Number of restaurants offering gluten free options in the Italian province i
- LogCeliacs$_i$ = Number of people diagnosed with coeliac disease in the Italian province i
- LogInhabitants$_i$ = Number of people living in the Italian province i
- LogEducation$_i$ = Number of people holding a Bachelor's degree in the Italian province i
- LogTourism$_i$ = Number of tourist visits in the Italian province i
- LogIncome$_i$ = Per capita income in the Italian province i
- LogRestaurants$_i$ = Total number of restaurants operating in the Italian province i
- LogValue_Added$_i$ = Value added at basic prices in the Italian province i
- Organic$_i$ = Dummy variable taking value of 1 if province i is ranked top five in Italy for the number of restaurants using at least 70% of organic ingredients, or 0 if otherwise

My dependent variable is represented by the number of restaurants offering gluten free products. The observations refer to the 107 Italian provinces.
The independent variables that I chose to include in the regression in order to explain the phenomenon are:

- Number of People Diagnosed with Coeliac Disease: this is my main independent variable, and it represents how many people are affected by coeliac disease in each Italian province. The source of the data is the "Relazione Annuale al Parlamento sulla Celiachia - anno 2020" ("Annual Coeliac Disease Relation to the Parliament - year 2020"), provided by the Italian Ministry of Health. The number of individuals suffering from coeliac disease was, however, only collected at regional level. Since my regression refers to the 107 Italian provinces, I was required to employ data at province level. Nevertheless, data on coeliac disease diagnoses

collected at province level is not available. In order to obtain data at province level, the figures were apportioned by the proportion of people living in a specific province over the total number of people living in the considered region.

- Inhabitants: a variable representing the number of people living in the considered Italian province. I chose to include this variable as I assumed that provinces with more inhabitants are more likely to register a higher number of restaurants providing gluten free options. Provinces with more residents are exposed to a wider set of customers with specific dietary requirements, and, therefore, should be more sensitive to the needs of coeliacs. Hence, I believe the number of inhabitants to be a major determinant.
  The data is taken from ISTAT, and it reports the number of inhabitants up to January 1st, 2020.

- Education Level: a variable expressing the number of people in each province who hold a Bachelor's degree. I added this variable because I deemed likely that more educated people are more aware of the increasing number of coeliac disease diagnoses. Consequently, they might be more responsive to such trend, and more willing to expand their offer by introducing gluten free products.
  The data is extracted from ISTAT, and it refers to 2011.

- Tourism: a variable reporting the number of tourist visits in each Italian province. I decided to include this variable since I reckon that the provinces registering the highest numbers of tourist visits might be more sensitive to the increasing need of fulfilling specific dietary requests. Especially, coeliac disease cases are rapidly growing everywhere in the world; it is not an Italian national phenomenon only. Thus, tourism appears to be a relevant factor in determining the number of restaurants offering gluten free dishes.
  The data is obtained from a survey conducted by Banca d'Italia and it refers to 2020.

- Income: a variable representing the level of per capita income in each Italian province. This variable was included based on the assumption that, as gluten free food is more expensive and expanding the offer of a restaurant can be a costly process, richer provinces might be more prone to offer gluten free options.
  The source of the data is the Italian national daily business newspaper "Il Sole 24 Ore", and the figures refer to 2016.

- Number of Restaurants: a variable expressing the total number of restaurants operating in each Italian province. The rationale behind including this variable is that provinces with more restaurants in total are more likely to also present a higher number of restaurants providing gluten free products.

  The data is taken from the seventh edition of "Osservatorio sulla demografia d'impresa nelle città italiane e nei centri storici" ("Observatory on business demography in Italian cities and historic centres"), published by Confcommercio-Imprese per l'Italia, the largest business association in Italy, and it refers up to June 2021.

- Value Added: a variable representing the value added at basic prices in each province. This variable aims to display the different economic picture in the different Italian provinces. As for the income, I included this determinant based on the assumption that restaurants in richer provinces might be more willing to provide gluten free dishes.

  The data is extracted from an analysis of Unioncamere, the Italian Union of Chambers of Commerce, Industry, Crafts and Agriculture, and Centro Studi delle Camere di Commercio Guglielmo Tagliacarne. The figures refer to 2020.

- Organic: a dummy variable taking value of 1 if the province is ranked top five in Italy for the number of restaurants using at least 70% of organic ingredients, or 0 if otherwise. The five provinces concerned are Bologna, Forlì Cesena, Rome, Milan, and Florence. I chose to add this variable in order to try and account for the rising popularity of eating gluten free not as a need, but as a choice, because considered healthier by common belief. Actual data on the number of people purchasing gluten free food without the need to is not available. The reason behind this explanatory variable is, therefore, capturing the increasing tendency towards healthy eating in the Italian provinces. I thought that provinces whose residents are more attentive in the selection of their food and more sensitive to healthy eating might also be more sensitive to specific dietary needs, such as the gluten free diet.

  The ranking is taken from Bio Bank, the Italian organic products database, and it refers to 2020. The objective of this variable is to highlight organic and healthy foods trends in the Italian provinces.

The regression is logarithmic, specifically, since both the dependent and independent variables are specified in logarithms, it represents a log-log model. In such a model, a 1% change in X is associated

with a β_1% change in Y. I chose to employ the logarithmic model because its understanding is more intuitive.

When the variance of the conditional distribution of the error term u_i given X_i, *var* $(u_i \mid X_i = x)$, is constant for i = 1, …, n and does not depend on X_i, the error term u_i is defined as homoskedastic. If this is not the case, the error term is defined as heteroskedastic (Stock et al., 2015). If the error term is homoskedastic, it is possible to use simplified formulas to compute the variances of the estimators. Consequently, there is a specialized formula that can be employed to compute the standard errors of the estimators, known as the homoskedasticity-only-standard error. As suggested by the name, such formula is incompatible with heteroskedastic errors. In contrast, since homoskedasticity is a peculiar case of heteroskedasticity, standard error formulas that are valid for heteroskedastic errors produce valid statistical inferences even in the case of homoskedasticity. These standard errors are called heteroskedasticity-robust standard errors (Stock et al., 2015). It follows that, as heteroskedasticity-robust standard errors are applicable both with heteroskedastic and homoskedastic error, the simplest solution to avoid any issues is to use robust standard errors. I, in fact, chose to employ heteroskedasticity-robust standard errors in my empirical analysis.

The Results

Using the statistical software Stata, I ran four similar linear regression models, characterized, however, by essential differences.

The first regression is:

$$LogGlutenFree\_Restaurants_i = \beta_0 + \beta_1 LogCeliacs2020_i + \beta_2 LogInhabitants_i + \beta_3 LogEducation_i + \beta_4 LogTourism_i + \beta_5 LogIncome_i + \beta_6 LogRestaurants_i + \beta_7 LogValue\_Added_i + \beta_8 Organic_i$$

VARIABLES	(1) Model 1
Log_Celiacs2020	0.796
	(0.544)
Log_Inhabitants	-0.571
	(0.665)
Log_Education	0.854***

	(0.266)
Log_Income	-3.189***
	(0.851)
Log_Tourism	0.0204
	(0.0779)
Log_Restaurants	-0.0949
	(0.169)
Log_ValueAdded	1.370***
	(0.393)
Organic	-0.160
	(0.297)
Constant	16.23**
	(6.311)
Observations	104
R-squared	0.509

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 11 (Generated on Stata on the base of collected data)

This first model employs the number of people affected by coeliac disease measured in 2020.
Even though the data refers to the 107 Italian provinces, the number of observations reported is only 104. This is because the statistics on the total number of restaurants are missing for three provinces: data on the provinces of Rome, Milan, and Naples was unfortunately unavailable.
R^2 is a measure of fit which portrays the fraction of the variance of the dependent variable that is predicted by the regressors. An R^2 near 1 implies that the regressors are good at predicting the values of the Y, an R^2 close to 0 suggests the opposite (Stock et al., 2015). In the model above, R^2 is about 51%, so the regressors are pretty good at predicting the response variable, as they explain about half of its variance. Despite this, when considering the R^2 it is important not to jump to premature conclusions, as it is easy to read more into such measure of fit than appropriate. One must remember that: an increase in R^2 does not necessarily mean that an added variable is statistically significant; a high R^2 does not mean that the regressors are a true cause of the dependent variable; a high R^2 does not mean that there is no omitted variable bias; a high R^2 does not necessarily mean that you have the most appropriate set of regressors, nor does a low R^2 necessarily mean that you have an inappropriate set of regressors (Stock et al., 2015).
In order to interpret the results obtained, the coefficients must be analyzed. They illustrate the relationship observed between the predictor and the response variable.

The table exhibits that a 1% increase in the number of 2020 diagnoses results in approximately a 0.8% increase in the number of restaurants providing gluten free dishes. Nevertheless, if we test the hypothesis that $\beta_1 = 0$, we notice that we cannot reject it. The p-value represents the minimum value (α) for which the null hypothesis is rejected: the null hypothesis is rejected if the p-value < α. If we look at the p-value of the concerned coefficient, we can conclude that the null hypothesis cannot be rejected at any significance level. Consequently, the number of people suffering from coeliac disease is not statistically significant. The result implies that the rise in coeliac disease diagnoses does not have an impact on the quantity of restaurants offering gluten free food and is in contrast with the main assumption the model is based on. A possible explanation for this outcome could be that, for instance, as previously discussed, using the number of people with coeliac disease does not allow to accurately reflect the current actual number of people following a gluten free diet. Excluding people who are gluten sensitive or allergic to wheat means disregarding a large share of potential customers. Anyhow, even if the main independent variable is not statistically significant, it shows reasonable magnitude and sign.

The number of inhabitants, the tourist inflow, and the number of restaurants are not statistical significant. Hence, it cannot be said that they influence the response variable.

The variable Organic, as it is a dummy variable, is the only one not expressed in logarithmic form. Its coefficient is, therefore, to be read differently from the other coefficients. If the dummy takes value 1, i.e. the province is ranked top five in Italy for the number of restaurants using at least 70% of organic ingredients, the number of gluten free restaurants in the province decreases by circa 16%. However, this variable as well is not significant.

The variables that instead show statistical significance are the education level, the income, and the value added. As expected, when the number of people holding a Bachelor's degree rises by 1%, the number of restaurants with gluten free options grows by 0.85%. Similarly, when the value added at basic prices goes up by 1%, the dependent variable grows by 1.37%. However, differently from what I had assumed, the income displays a negative relationship with the quantity of gluten free restaurants: as income increases by 1%, Y decreases by 3.2%.

Having obtained unexpected results and many not statistically significant coefficients may be due to the fact that we do not dispose of enough observations.

It is also relevant to consider that the COVID-19 pandemic that hit the world in 2020 largely affected the restaurant industry and its impact is not accounted for in the regression. For example, it is possible that some of the restaurants providing suitable food for people with coeliac disease might have been forced to shut down due to the difficulties arisen from Covid. Several of the shops providing gluten free food already face a reduced number of potential clients, as they do not also offer regular, with

gluten products; the pandemic could have induced restrictions and further cuts on the number of customers that could have made running the business unprofitable.
The next regression that we are going to analyze is not subject to such complication since it pertains to a pre-Covid period.

The second regression model is:

$$LogGlutenFree\_Restaurants_i = \beta_0 + \beta_1 LogCeliacs2018_i + \beta_2 LogInhabitants_i + \beta_3 LogEducation_i + \beta_4 LogTourism_i + \beta_5 LogIncome_i + \beta_6 LogRestaurants_i + \beta_7 LogValue\_Added_i + \beta_8 Organic_i$$

With respect to the previous regression, the essential difference is that the data on the number of individuals suffering from coeliac disease refers to the year 2018. The rationale behind the choice of running such regression is that making the necessary adjustments to be able to supply gluten free options might require some time. Accordingly, the decision of expanding the restaurant's offer would become concrete only after a certain timeframe. The restaurants providing gluten free food, hence, might have chosen to do so based on the statistics of preceding years.

VARIABLES	(1) Model 1
Log_Celiacs2018	1.180**
	(0.538)
Log_Inhabitants	-0.959
	(0.669)
Log_Education	0.909***
	(0.279)
Log_Income	-3.377***
	(0.838)
Log_Tourism	0.0354
	(0.0800)
Log_Restaurants	-0.124
	(0.169)
Log_ValueAdded	1.340***
	(0.391)
Organic	-0.234
	(0.295)

Constant	20.31***
	(6.292)
Observations	104
R-squared	0.532

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.

Figure 12 (Generated on Stata on the base of collected data)

The R^2 in this model is almost the same as in the previous regression: the coefficients are able to explain about half of the variance of the dependent variable. The two models, however, diverge fundamentally. When using data on the number of people affected by coeliac disease in 2020, the coefficient is not statistically significant; in this case, instead, using the data on the number of diagnoses in 2018, the coefficient obtained shows statistical significance. As depicted by table in Figure 9, a 1% increase in the number of coeliacs registered in 2018 leads to a 1.18% rise in the number of restaurants with gluten free options. This outcome seems to confirm my initial hypothesis that the boom of coeliac disease diagnoses results in an increment in the quantity of restaurants willing to extend their menus to fulfill the requirements of those who need to follow a gluten free diet.

Not surprisingly, the variables showing statistical significance, apart from the number of people suffering from the disease, are the same as in the first regression, i.e., level of education, income and value added. The coefficients of the level of education and of the value added at basic prices have reasonable size and sign. Similarly as before, we obtain that a 1% increment in the level of education results in a 0.9% growth in the number of gluten free restaurants, and that a 1% increment in the value added results in a growth of the response variable of 1.34%. Again, we get that the coefficient of the variable Income is a negative value. This result is opposed to my initial assumption and logically tough to explain. It does not seem to be realistic that an increase in the level of education corresponds to a decrease in the number of restaurants supplying gluten free food. A possible cause for this odd value, like already mentioned, could be that the number of gathered observations might not be sufficient to produce significant results.

The remaining independent variables are not statistically significant. Their coefficients exhibit similar magnitude and the same sign as the corresponding coefficients obtained in the regression model based on 2020 data.

The third and fourth regression models are:

$$LogGlutenFree\_Restaurants_i = \beta_0 + \beta_1 LogCeliacs2020_i + \beta_2 LogInhabitants_i + \beta_3 LogEducation_i + \beta_4 LogTourism_i + \beta_5 LogIncome_i + \beta_6 LogRestaurants_i + \beta_7 LogValue\_Added_i + \beta_8 Celiacs2020Income + \beta_9 Organic_i$$

$$LogGlutenFree\_Restaurants_i = \beta_0 + \beta_1 LogCeliacs2020_i + \beta_2 LogInhabitants_i + \beta_3 LogEducation_i + \beta_4 LogTourism_i + \beta_5 LogIncome_i + \beta_6 LogRestaurants_i + \beta_7 LogValue\_Added_i + \beta_8 Celiacs2018Income + \beta_9 Organic_i$$

These two models maintain the same variables of the earlier analyzed regressions; the first one is run employing the data on the number of diagnoses in 2020 and the second one employing the data collected in 2018. The critical difference with respect to the previous models is the introduction of a new regressor, CeliacsIncome. This variable is denominated interaction term or interacted regressor and represents the product between the variables Celiacs and Income. As there might be an interaction between the two terms, by including the new regressor we allow the effect on the number of gluten free restaurants of the number of diagnoses to depend on the income. Even this newly added regressor is considered in its logarithmic form, so as to facilitate the interpretation of the results.

	(1)
VARIABLES	Model 5
Log_Celiacs2020	12.03
	(7.614)
Log_Inhabitants	-0.532
	(0.663)
Log_Education	0.883***
	(0.268)
Log_Income	5.230
	(5.541)
Log_Tourism	0.0176
	(0.0783)

Log_Restaurants	-0.0956
	(0.169)
Log_ValueAdded	1.337***
	(0.390)
Organic	-0.0600
	(0.312)
Log_Celiacs2020Income	-1.124
	(0.754)
Constant	-68.28
	(56.31)
Observations	104
R-squared	0.517

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 13 (Generated on Stata on the base of collected data)

VARIABLES	(1) Model 1
Log_Celiacs2018	13.95*
	(7.469)
Log_Inhabitants	-0.924
	(0.667)
Log_Education	0.943***
	(0.281)
Log_Income	6.070
	(5.376)
Log_Tourism	0.0334
	(0.0802)
Log_Restaurants	-0.123
	(0.169)
Log_ValueAdded	1.305***
	(0.387)
Organic	-0.119

	(0.314)
Log_Celiacs2018Income	-1.278*
	(0.741)
Constant	-74.48
	(54.74)
Observations	104
R-squared	0.542

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Figure 14 (Generated on Stata on the base of collected data)

We notice that, as expected when a new variable is introduced, the R^2 slightly augmented for both models. Thus, the fraction of the variance of the dependent variable that is predicted by the regressors narrowly increased. In both models, the coefficient value for the number of people suffering from coeliac disease grew considerably. In the 2020 model in Figure 10, we can observe that a 1% increase in the number of coeliacs in 2020 lead to a 13.95% increase in the number of gluten free restaurants. The value is, however, not statistically significant. Figure 11 displays a similar effect on the variable concerning the amount of people affected by the disease in 2018. What is remarkable in the second model is that when we add the interaction term, not only the magnitude of the coefficient rises, but also it becomes not statistically significant.

The number of inhabitants, tourists, restaurants, and the dummy variable Organic all show no statistical significance, as in the previous regressions. The level of education and the value added, consistently with the results of the first two regressions, show statistical significance and size and magnitude almost identical to what obtained before. A noteworthy change, instead, can be pointed out in the variable reflecting the income of individuals: if the results discussed in regression one and two highlighted a negative relationship between the income and the dependent variable, the introduction of the interaction term reverses the relationship. We obtain that in 2020 a 1% increase in the income leads to a 5.23% increase in the number of gluten free restaurants; in 2018, as income rises by 1%, the dependent variable rises by 6.07%. A positive coefficient is a more reasonable outcome, and it is in line with my initial hypothesis. Nevertheless, the change in sign is not the only difference arising from the addition of the new regressor: the coefficient also becomes not statistically significant, both in 2020 and in 2018.

As for what concerns the latest included regressor, CeliacsIncome, we get that in 2020 a 1% increase in such variable results in a decrease of 1.12% in the response variable; in 2018, we get that the

number of restaurants providing gluten free meals would decrease by 1.28%. The coefficients that we obtained represent the effect of a 1% increase in the number of coeliacs and in the income, above and beyond the sum of the individual effects of a 1% increase in the quantity of coeliacs alone and a 1% increase in the income alone. In both of the years examined, the interaction term appears, however, to be not statistically significant.

It would have been interesting, moreover, to run another regression employing the growth rates of the number of diagnoses over the years. Nonetheless, as explained in the section dedicated to the presentation of the data set, the data on the number of diagnoses provided by the Italian Ministry of Health is only collected at regional level. To overcome such obstacle, I had apportioned the figures by the proportion of people living in a specific province over the number of people living in the contemplated region. Because of the apportionment procedure, it was not possible to compute the growth rates at province level. I, thus, tried to modify my data set and run an additional regression at regional level which included the regional growth rates. Such rates were calculated on the base of the statistics on the number of individuals suffering from coeliac disease from 2014 to 2020.
The results of this regression are, however, too unstable, as they are merely based on 20 observations.

Conclusion

The popularity of the gluten free diet is now higher than ever and there is spread awareness of coeliac disease and of the other gluten-related disorders. Several statistics show that the number of individuals with the necessity of avoiding gluten is growing sharply, and the restaurant industry is adapting accordingly.

The objective of my analysis was to investigate, through the use of regression models, how the recent boom of coeliac disease diagnoses is impacting the Italian restaurant industry. The outcome of my study emphasized that, as expected, there is a positive correlation between the number of diagnoses and the number of restaurants willing to offer suitable meals for people suffering from coeliac disease. The coefficients that I obtained in the regression models pertaining to the number of people diagnosed with coeliac disease were not always significant. Nevertheless, a possible explanation of this result may be that the available observations were not enough. Moreover, it is relevant to acknowledge that only considering the number of coeliac disease diagnoses does not accurately reflect the current actual number of people following a gluten free diet.

In accordance with the pattern examined, it can be concluded that the gluten free market is destined to expand. Increasing attention will be given to the 'gluten free' claim, and it is foreseeable that a growing amount of restaurants will be willing to enrich their menus by providing gluten free options. Thus, in the next few years, the restaurant industry will, inevitably, become more and more inclusive towards people affected by food allergies and conditions like coeliac disease.

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