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The Role of the Economy on Attitudes Towards STEM Careers:

How the 2008 Financial Crisis Affected the Pursuit of STEM subjects at the Leaving Certificate Exam

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Declaration

I hereby declare that this is entirely my own work and that it has not been submitted as an exercise for the award of a degree at this or any other University. I agree that the Library may lend or copy this dissertation on request.

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Beatriz Gietner 27/09/2018

Summary

This year marks the tenth anniversary of the 2008 financial crisis, an event that shook the world and left a mark in many families across the globe. The people of Ireland had to revaluate how to better reallocate their resources and how to prepare the next generation for a scenario where the future is more complicated to predict. The aim of this study is to clarify how the financial crisis reflected on the choices of second-level students in Ireland when it comes to STEM subjects.

In order to see how the 2008 financial crisis affected students in relation to their career prospects (with a focus in STEM-related careers), I mapped the amount of students choosing to sit STEM subjects at the Leaving Certificate - which is the exam that grants them access to third-level institutions in Ireland - from 1993 to 2015, and the amount of points necessary for admission in STEM-related courses at third-level institutions from 2005 to 2016.

I found a great disparity in numbers between the STEM subjects, and a considerable difference between the genders. There was an overall increase in the number of students sitting Agricultural Science, Applied Mathematics, Biology and Chemistry, and an overall decrease in the number of students sitting Engineering, Mathematics, Physics, and Physics and Chemistry. There was also a significant increase in the points necessary for third-level admissions in STEM-related courses, especially in the areas of Healthcare, Chemistry, Nanotechnology, Biology, and Computer Science.

Albeit somewhat inconclusive due to lack of proper statistical methods, this study can be considered the first step towards a better understanding on how students' attitudes towards Science change during periods of financial instability.

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Table of Contents

List of Abbreviations

CAO	Central Applications Office
CSO	Central Statistics Office
DES	Department of Education and Skills
DCU	Dublin City University
GDP	Gross Domestic Product
GNP	Gross National Product
GNI	Gross National Income
NUIG	National University of Galway
OECD	Organisation for Economic Cooperation and Development
SCCT	Social Cognitive Theory
STEM	Science, Technology, Mathematics and Science
TCD	Trinity College Dublin
UCC	University City Cork
UCD	University City Dublin
UL	University of Limerick
WITS	Women in Technology and Science

Appendices

List of Figures

1 Introduction

The study of Human Capital - the knowledge, skills, competencies and other attributes embodied in individuals or groups of individuals acquired during their life and used to produce goods, services or ideas in market circumstances – goes back a long way. What started as an idea with Adam Smith in the eighteenth century and was later developed into a theory by Gary Becker, has now become a valuable area of study. The study of Human Capital is important not only due to its financial and political implications, but because it helped to alleviate poverty and increase human conditions by explaining how to better allocate resources and develop markets.

Knowledge is the most important of all Human Capital abilities, and the links between education and income help to elucidate why and how society evolves to progress. Both Smith and Becker were economists, and were used to think as such. This assumption implies that they saw human actions and interactions as responses to external stimuli, often trading one action for another or one thing for another by weighting the costs of such actions and things.

Becker assumed that people would conscientiously calculate how much to invest in their own human capital, and this includes the cost of acquiring education. By thinking about expected future earnings from different career choices and considering the cost of acquiring the education to pursue these careers (including time spent in the classroom), people decide if pursuing certain education is worth it or not. Although in reality decisions have to be made under uncertainty and complicated motivations, simplified assumptions about people being purposeful and rational in their decisions lay at the core of Becker's Human Capital theory. Considering such theory, it is natural to assume that stressful times make people revaluate where and how to allocate their resources, and the 2008 financial crisis can be characterized as such.

Under unstable circumstances, people tend to play safe (Dow and Werlan, 1994; Van Dijk and Zeelenberg, 2007). It is expected that when deciding for a major, people tend to think

about the pecuniary returns to such major. Depending on the country and the period considered, the labour market rewards certain careers more than others. Ireland had to rethink its economy back in 2008, and the youth more than the others, which was difficult exactly because it is hard to predict how career prospects will behave under a crisis. This study starts with the assumption that, due to Ireland's relatively open economy and openness to scientific and technological innovation, students would go for majors in these areas, especially after the financial crisis. In order to do so, it was needed to map the change in the number of students sitting STEM subjects at the Leaving Certificate exam before and prior to the crisis.

Chapter 2 lays the foundation for such assumption and gives a substantial historical and theoretical background for all the important decisions made along the rest of this study.

Chapter 3 contains an explanation of how the data was selected, collected, and plotted, including the processes through which the data was analysed.

Chapter 4 includes the main results found from the data analysis, separated by subject, gender, exam level and mapped along a twenty-two years period of time.

Chapter 5 discusses why the main results were expected, the reasons why I decided to extend the research to third-level institutions and how the existence of single-sex schools still perpetuates the stigma of STEM careers being a boys' thing.

Chapter 6 closes the dissertation with a summary of all the findings and suggestions for new studies.

This study was carried in order to answer to the questions:

- Did the economic recession in Ireland have any impact on students choosing STEM subjects in school?

- Did the economic recession in Ireland have any impact on students choosing STEM courses in Irish universities?
- Does the fact that there are still single-sex schools in Ireland contribute to the gender disparity observed at Leaving Certificate subject choices?

With this study I hope to contribute to the idea that education and economy are intrinsically connected. Because of it, depending on how one chooses to act - being her a sixteen years old starting her Senior Cycle or a policy-maker deciding where to allocate public and private funds - one does it by thinking on the price others will have to pay.

2 Literature review

"The acquisition of… talents during… education, study, or apprenticeship, costs a real expense, which is capital in [a] person. Those talents [are] part of his fortune [and] likewise that of society"

Adam Smith, 1776

2.1 Introduction

Deciding how much time and money to invest in their education is one of the most important economic decisions young adults make during the course of their lives (Koch, Nafziger and Nielsen, 2015). There is a large literature attempting to estimate the returns to schooling with earnings data. As pointed out by Manski (1993), it is the returns perceived by students and/or their parents that will influence actual schooling decisions (Jensen, 2010). Economic models of educational choices suggest that students' college majors' decisions are guided, in part, by the future earning streams associated with the different majors available to them (Altonji and Zimmerman, 2017).

As a superficial framework to investigate if pecuniary career returns were a predictor of career choice in the aftermath of the 2008 financial crisis, this study makes use of the theory of social cognitive career theory (Lent, Brown and Hackett, 1994). Seeing that lifetime earnings are influenced strongly by a student's college major (Stinebrickner and Stinebrickner, 2003), it is expected that information regarding pecuniary career returns

provided by parents, teachers, the media, and peers would influence a student's choice of college major.

The financial crisis of 2008 brought Ireland to its knees and made the waves across all sectors, from education to agriculture. Such a shocking event was partly responsible for revaluating people's perspectives of the future. For example, in response to the crisis, five successive national budgets in Ireland implemented a range of austerity measures, beginning in 2009 (Lillis and Morgan, 2012). These austerity measures impacted all households, and some of the financial crisis spillover effects can be observed when we look at Ireland's secondary education.

There is a common perception that science, technology, mathematics and engineering (STEM) majors and careers are well rewarded in pecuniary terms, and are almost a guarantee of financial stability in an unstable and globalized environment (Hossain, 2012). This perception is rooted in substantial and well-established research by several authors in many countries (Hall et al., 2011; Kim, Tamborin and Sakamoto, 2015; Melguizo and Wolniak, 2012; Winters, 2014).

Almost all third-level institutions in Ireland use the Leaving Certificate exam as their admission process. The Leaving Certificate marks the end of a two-year secondary education known as the Senior Cycle. The amount of points earned in the Leaving Certificate is used by the Central Applications Office (CAO) to award places to students at third-level institutions. Students choose to be evaluated on between three to five subjects of their choice plus mandatory (with a few exceptions) English, Irish and Mathematics. Between subjects of their choice there are seven that are considered STEM-related: Agricultural Science, Applied Mathematics, Biology, Chemistry, Engineering, Physics, Physics and Chemistry (Technology was offered only from 2009 onwards).

By analysing the number of students choosing to sit STEM subjects at their Leaving Certificate exam before and after 2008, we can infer, to a certain degree, if the financial crisis somewhat affected the students' pursuit of STEM majors and, therefore, their envisioned STEM careers. The importance of educational credentials for an individual's labour market success is one of the best established facts of sociology and labour economics (Lee and Brinton, 1996). Considering that students often pursue careers based on the area/subject they

majored in, and that the labour market most of the time requires third-level credentials when it comes to STEM and other careers (Wai, Lubinski and Benbow, 2009), it was natural to assume the correlation between choice of major and expected pecuniary career returns (Altonji, Arcidiacono and Maurel, 2016; Arcidiacono, 2004; James and Alsalam, 1993; Moakler J and Kim, 2014; Oreopoulos and Petronijevic, 2013).

2.2 Returns to education

There are two non-exclusionary ways of analysing the role of education in society: education with a purpose (education as a means to an end) and education for education's sake (education as an end-in-itself - an extension of Kantian ethics). Both analyses are valid depending on what educational framework and environment one chooses to focus on. In this study I chose to focus on the former. From a sociological point of view, education is worth seeking due to its increase in human capital. From an economic perspective, education is worth seeking due to its increase in pecuniary and non-pecuniary returns. Even though the basic Mincer model does not allow for the latter, non-pecuniary returns may create private returns through externalities that are as great – if not greater – than the direct effect of education on earnings (Dickson and Harmon, 2011).

It is a well-studied fact that people with more education make more money than those with less education. Although human capital returns are somewhat uncertain and unpredictable (Wilson and Briscoe, 2004), the pecuniary returns to education, both private and social, are measurable up to a point.

Gunderson and Oreopoulos (2010) define the returns to education as "the financial rate of return to investing in an additional year of schooling, obtained by comparing the additional earnings from an additional year of education with the cost of acquiring the additional education" (Gunderson and Oreopoulos, 2010). Becker's canonical model of human capital views education as an investment, where costs are compared to the discounted stream of expected future benefits, primarily in the form of greater wages (Jensen, 2010).

When talking about returns to education, it is important to keep in mind they are individual and context specific, which causes them to differ at private and social instances, and to

produce quite substantially different effects on developed and developing countries. Even within and across races, genders and ages there are substantial differences - Henderson, Polachek and Wang (2011) found that Blacks have higher returns to education than Whites and younger workers have higher returns than older workers. When it comes to private returns, what one would gain from more years of schooling highly depends on one's background, her motivation, the quality and type of schooling, and the economy system in place (Gunderson and Oreopoulos, 2010). The external benefits of education (i.e. the public benefits of education that spillover to benefit others in the society) include education's direct benefits to the development of civic institutions that contribute slowly over long periods of time to the rule of law, democracy, human rights, and political stability (McMahon, 2010).

Increased investment in education is shown to lead to higher productivity and earnings for the individual and, similarly, such investment results in significant social rates of return (Wilson and Briscoe, 2004). The earnings of more educated people are almost always well above average, although the gains are generally larger in less-developed countries (Becker, 1994). Certain economic systems facilitate financial returns to education by allowing innovation to thrive, which also allows for the production of wealth and its effective allocation.

Although there is room for deeper research, these differences between countries' economic systems could be due to differential exposure to market forces and differential access to quality education (Becker, 1994). Differences in relative earnings between countries reflect a number of factors such as the demand for skills in the labour market, minimum wage legislation, the strength of unions, collective agreements, the supply of workers with various levels of educational attainment, the work experience of workers with high and low levels of schooling, and the distribution of employment among occupations (OECD, 2007).

Both secondary and higher level education raise a person's income, even after netting out direct and indirect costs of schooling, and after adjusting for the better family backgrounds and greater abilities of more educated people (Becker, 1994). But it is vital to take into account the risks associated with education investment decisions. Risks may play an important role in an individual's education investment decision - and also a government's educational investment level, which should be taken into consideration when dealing with new plans of education investment (Dickson and Harmon, 2011).

Generally, earnings rise with education level and they increase at an increasing rate in the immediate post education years, continue to increase at a slower pace, and then flatten as individuals approach retirement (Ladd and Fiske, 2012). Returns to education tend to be around ten percent, typically ranging from six percent to fifteen percent, and they tend to be higher for professional fields like engineering, medicine, business, and sciences (Gunderson and Oreopoulos, 2010). The literature documents substantial differences in the return to various majors, with math-oriented and technical majors earning approximately thirty percent more than nontechnical majors, and large differences remain even after accounting for the ability bias that leads innately more capable individuals into technical majors (Eide and Showalter, 2010). The returns are highest at the primary level, but the returns to higher education are also high. The education of current graduates also benefits the earnings and quality of life of others in future generations. However, these future benefits cannot be measured directly (McMahon, 2010).

The exact proportion between the phenomena that account for the total amount of estimate returns is uncertain. Most researchers agree that schooling affects earnings both by improving skills and by signalling skills (being them acquired or not). Lange (2007) estimates that the contribution of signalling to the returns to schooling is less than twenty five percent (Lange, 2007), whilst Caplan says it revolves around eighty percent (Caplan, 2018). Despite disagreements between economists, several important works over the last decade that establish causation between education and earnings have made the case for schooling as an investment (Aghion et al., 2009). Private rates of return to schooling can be used to analyze the distributional effects of education finance programs, which can guide public policy with respect to the design of programs and the crafting of incentives that promote both private and public educational investment (Patrinos, 2016).

Understanding the causal relationship between education and the financial results to such education is important for addressing a range of questions of practical and policy importance (Gunderson and Oreopoulos, 2010). But necessary information might not be there, or actually anywhere. Such scenario is damaging to a student's schooling and career planning, and to society around her. Jensen (2010) found that students do not have accurate information on earnings and appear to underestimate the returns to schooling (Jensen, 2010), which leads to conclude that, under dreary situation, students cannot be expected to choose the option that would maximize utility (Altonji, 1993). In the Irish context, Delaney et al. (2011) showed

how “an observed gap in educational attainment by social class at the time of entry to university is all but eliminated by the graduation, but there persists a large and significant gap in the expectations of students whereby poorer students have lower wage expectations” (Dickson and Harmon, 2011).

Ireland is a country in which one can observe huge differences across the rural and urban divide. Localism accounts for major discrepancies in education and wealth, and, consequently, future aspirations. Data on earnings available to youths may come from the individuals they can observe around them, which could lead to inaccuracies (Jensen, 2010). Due to heterogeneities, subjective expectations on earnings can vary massively depending on what part of the country one finds herself at. For example, youths in rural communities or small towns where few or no adults have any education will have little information from which to infer the returns, including potential returns in the urban sector (Jensen, 2010). This calls for an increase in awareness dissemination not only in pecuniary returns to education, but also on education as a vector for social progress.

2.3 Education and economic growth

In his well-acclaimed “Human Action”, Austrian economist Ludwig von Mises states that “Human action is purposeful behaviour (...) Action is will put into operation and transformed into an agency, is aiming at ends and goals.” (Mises, 1949). Along its hundreds of pages, he delves into a search for what drives human decision-making through a rational investigation of the relationship between man and his surroundings; particularly, the exchange of one state of affairs for another, more satisfactory, state of affairs.

More than an extensive study on praxeology, Mises’ works were vital for the academic, economic and political expansion of Liberalism in the post-war era (Coyne, 2008). Although well defined by Bell (2014) as “a spectre that haunts Western political thought and practice” due to its followers dual-interpretation of Locke’s political philosophy, Liberalism lies at the core of every functioning democracy in the world. Nations that enjoy a relative economic freedom, due to its government allowing for an open-market economy system (at least to some extend) to take place, tend to experience a consequent economic growth (De Haan and Sturm, 2000).

In order for a nation to be wealthy, it must allow for wealth to be created. This is one of the reasons why freer economies are richer than closed economies. When individuals enjoy a relative degree of freedom to innovate, to trade within themselves and with other nations, it is inevitable to expect an increase in both gross domestic product (GDP), gross national product (GNP), and human development numbers. That is why the quality of the institutional environment and the quality of education are important for economic development. More wealth implies more resources to invest in education, which therefore can result in an even greater economic growth (if done correctly). Education may not have much impact in less developed countries that lack facilitating factors such as functioning institutions for markets and legal systems (Easterly, 2001).

Ireland is unusual in having a combination of fast economic growth and relatively even distribution of that growth. Economic growth and education have an interesting relationship: when more financial resources are available, more a nation can invest in education and research; which, in turn, can result in greater economic growth (Salter and Martin, 2001; Toole, 2012). By increasing cognitive skills of the population through education, it is observed a rise in individual earnings, distribution of income and economic growth (Hanushek and Wössmann, 2007). But not just that: economic growth resulting from a relative free-market economic system also allows for a more developed and specialized labour market (Berggren, 2003; Doucouliagos and Ulubasoglu, 2006) and is directly correlated to opportunity-motivated entrepreneurial activity (McMullen et al., 2008).

Hanushek et al. (2008) stated that the more open the economy, the more important it is that a country's students are acquiring high levels of cognitive skills, and that when the average number of years of schooling in a country was higher, the economy grew at a higher annual rate over subsequent decades (Hanushek et al., 2008). In fact, across the 50 countries, each additional year of average schooling in a country increased the average 40-year growth rate in GDP by about zero point thirty seven percentage point (Hanushek et al., 2008).

As highlighted by Hanushek and Wöessmann (2011), there are three main mechanisms through which education may affect economic growth:

- Education can increase the human capital inherent in the labour force, which increases labour productivity and thus transitional growth toward a higher equilibrium level of output (Mankiw et al., 1992);
- Education can increase the innovative capacity of the economy, and the new knowledge on new technologies, products and processes promotes growth (Aghion and Howitt, 1998);
- Education can facilitate the diffusion and transmission of knowledge needed to understand and process new information and to successfully implement new technologies devised by others, which again promotes growth (Benhabib and Spiegel, 1994).

It is well documented that better-educated workers have more favourable labor-market outcomes than those with less schooling, and that well-educated labour force is critical for a nation to compete in an increasingly global economy that rewards knowledge and skills (Brewer, Hentschke and Eide, 2010). The effect of educational quality on growth seems significantly larger in countries with a productive institutional framework, so that good institutional quality and good educational quality can reinforce each other (Hanushek and Wöessmann, 2011).

A considerable dispute addresses whether it is the level of years of schooling or the change in years of schooling that is the more important driver of economic growth (Krueger and Lindahl, 2001). Barro (2013), after an extensive analysis of relevant determinants of economic growth and investment relative to a panel of around 100 countries observed from 1960 to 1995, found that, with respect to education, growth is positively related to the starting level of average years of school attainment of adult males at the secondary and higher levels. Plus, the quality and quantity of schooling both matter for growth but quality is much more important (Barro, 2013).

CoCkx (2016) found that, in flexible labour markets, low-educated entrants are harmed by economic downturns, but the penalties are short-lived, and that high-educated youth are less adversely affected, but the penalties persist longer (CoCkx, 2016). This is the Irish case: the degree of openness of the Irish economy is exceptional, and its labour market is considered flexible (Doris et al., 2015). The Irish labour market is generally held to be flexible with

relatively low levels of job protection legislation, above average working time flexibility and above average functional flexibility, measured by the ease with which employers can change the content of work (Andranik 2008). It takes about ten years for young cohorts that enter the labour market during a downturn to catch up to cohorts that did not (CoCkx, 2016), therefore we can start to see the effects of the 2008 financial crisis starting to ease from this year onwards.

From the early 1970s the supply of skilled labour in Ireland has risen rapidly as a consequence of educational expansion; the supply of unskilled labour, on the other hand, fell quite rapidly from the early 1980s as a result of increasing educational participation at secondary level (Barrett, FitzGerald and Nolan, 2002). In the 1980s and the 1990s, Ireland experienced a rising demand for skilled labour due to the boom of the industrialised economies, which was accentuated by the scale of foreign direct investment in the high-technology sector (Barrett, FitzGerald and Nolan 2002).

The Irish economy was growing strong until the 2008 financial crisis. According to Doris (2015), after a period of very rapid growth from 1994 to 2007, when the average annual GDP growth rate was over seven percent, the economy collapsed and the average growth rate over 2008-2011 was minus one point seventy five percent; unemployment rate, having been relatively stable at four to five percent for most of the early 2000s, rose from four point five percent in 2007 to twelve percent in 2009 and continued to rise further to fourteen point six percent in 2011 (Doris, 2015). Another reason to see the pursuit of third-level education as a positive endeavour is that employment of those with a third level education in Ireland actually increased by 110,000 between 2007 and 2012 despite an overall fall in employment (O'Farrell, 2014).

Several recent studies suggest that education is important both as an investment in human capital and in facilitating research and development and the diffusion of technologies, with initial phases of education more important for imitation and higher education for innovation (Vandenbussche et al., 2006). Ireland has them both covered. Primary and secondary education is provided by the state, and while some students attend private fee paying schools the vast majority attend state funded schools (Delaney et at., 2011).

Irish pupils perform well on international evaluation exams such as the Trends in International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA). The country also has third-level institutions that foment entrepreneurial and technological mind-sets by developing partnerships with tech companies like Google and Microsoft. In the last twenty years, development of digital technology has caused dramatic changes in the global labour market. Nonetheless, the new jobs created in the high technology sector often demand college education (Wang, 2013).

Investments in quality education and well-developed relationships with market agents might help to explain how Ireland's has been steadily recovering from the 2008 financial crisis. By welcoming inflow of foreign capital and making use of the European single market, the Irish government tries to regain trust from its citizens. Globalization and a knowledge-based economy are inevitable, and they have caused - for better or for worse - dramatic changes to the character and functions of education in most countries around the world. The results of these changes only time can tell.

2.4 Expected earnings and choice of major

Altonji and Zimmerman (2017) showed that expected earnings do matter for student's choice of major, even after controlling for ability and career preferences, and students can differ in their forecasts of future expected earnings in different careers and majors precisely because they differ in their abilities to succeed in different majors and, subsequently, in various careers (Altonji and Zimmerman, 2017). Wiswall and Basit (2011) found that subjective beliefs about future major choice are positively and strongly associated with beliefs about self-earnings and ability, but when and how do these beliefs start to form?

At least when it comes to STEM majors, results indicate that the majority of students who concentrate in STEM make that choice during high school, and that choice is related to a growing interest in mathematics and science rather than enrolment or achievement (Maltese and Tai, 2011). Maltese and Tai (2011) also found in the U.S. that students who earned higher scores on eighth-grade science and mathematics achievements were more likely to complete degrees in STEM, as were those who agreed that science would be useful in their future (Maltese and Tai, 2011).

A large body of research shows that, for the majority of students, interest in pursuing a scientific careers is largely formed by age fourteen (Ormerod and Duckworth, 1975; Tai, Liu, Maltese and Fan, 2006). In Ireland, this hallmark coincides with the end of the Junior Cycle (and the sitting of the Junior Certificate exam) and the beginning of the Senior Cycle (and, therefore, the start of the preparation for the Leaving Certificate exam).

It is worth highlighting that most schools hesitate to allow students to study STEM subjects through their Senior Cycle if they did not study Science during their Junior Cycle. This creates a barrier for late term decisions of choosing a STEM major, but it indicates that, at least partially, students that choose to sit STEM subjects at their Leaving Certificate do that due to an early interest in science and are more likely to use their points to apply to STEM courses. While intuitively, it seems reasonable that both enrolment and achievement might be associated with earning a STEM degree, Maltese and Tai (2011) found that only the number of science classes completed in high school was positively associated with a STEM degree, an indication that high school course enrolment in STEM classes may be an indicator of STEM-related persistence at least in the U.S. (Maltese and Tai, 2011).

Career aspirations are represented by two indicators: expected jobs in the future and job demands on science literacy (within the science education context). Positive links were found between student career aspiration and several variables of science education, including educational outcomes, instructional quality, and home environment (Wang, 2013). At the secondary level, positive attitudes toward STEM, high achievement, and advanced coursework are associated with choosing a major in STEM (Maple and Stage, 1991; Trusty, 2002; Ware and Lee, 1988). Students who felt they had strong ability in science, and that the courses were challenging, were more likely to report plans for enrolling in advanced STEM coursework (Maltese and Tai, 2011).

According to Maltese and Tai (2011), there is a strong positive association between teachers emphasizing further study in science and discussing science careers and increased levels of student interest in science (Maltese and Tai, 2011). In Australia, Kennedy, Lyons and Quinn found that Year-10 Australian students believe teachers to be the most influential figure on their decision to pursue the study of science (Kennedy, Lyons and Quinn, 2014). Whilst this finding has potential to result in more students pursuing STEM careers, it also raises a

concern. In Ireland, secondary school teachers are professionally trained to be teachers, not to work within STEM fields. Only a minority of teachers of science have ever been practicing engineers or scientists themselves: hence, they lack the experiential knowledge necessary to illustrate the nature of work and careers in science and technology (Claussen and Osborne, 2013).

Due to lack of information regarding future career prospects, most students are left at the mercy of forecasts errors. This is damaging not only because students are not being exposed to basic social frameworks, but also because science education has an important role in developing the critical spirit of the independent thinker—as a force for challenging orthodoxies within and outside science. As explained by Claussen and Osborne (2013), "by explicitly teaching these skills, and pointing out to students that they are transferable to other domains, school science offers a means for students to see both the intrinsic value of their science classes for their own thinking and the extrinsic value for future employment" (Claussen and Osborne, 2013). Sometimes the teacher is the only information guide a student encounters, and not all parents can provide all sorts of information regarding career possibilities and prospects. We all might be missing opportunities: students by not choosing STEM majors, and society for not increasing its population's critical thinking.

In Ireland there are initiatives such as WITS (Women in Technology and Science) and Engineers Ireland STEPS Programme, which focus on a more practical, hands-on and purposeful side of science education and scientific careers. Such initiatives are partially funded by Science Foundation Ireland, an agency which funds research of the highest international quality and of strategic value. Science Foundation Ireland also organizes several science festivals throughout the country all around the year, and it has been quite successful in making science personal, local, and relevant. It would be interesting to see an increase in discussion within and outside classrooms about the types of jobs available in STEM, which can be achievable by and whenever possible having students to be in contact with local representatives of organizations in STEM fields.

2.5 Social cognitive career theory

Developed by Lent, Brown and Hackett (1994), social cognitive career theory (SCCT) aims to provide explanations to three interrelated aspects of career development: how basic academic and career interests develop, how educational and career choices are made, and how academic and career success is obtained. There is a complex interplay of factors that are involved in student entry and persistence in STEM, which can be partially explained by a framework based on SCCT. SCCT proposes that career choice behaviours are also shaped by contextual variables, such as supports - like financial support from the family - and barriers such as having to leave home for further education (Rogers and Creed, 2011). SCCT focuses on the reciprocity and interactions between individuals' cognitive processes and their environment (Thompson and Dahling, 2012).

According to Lent et al. (1994), SCCT describes how people's environments expose them to career-relevant activities that influence the development of self-efficacy, outcome expectations, interests, and goals which influence career choices and behaviours (Zikic and Saks, 2009). Career choices are not made under "optimal conditions" for everyone, and economic need, educational limitations, lack of familial support, or various other considerations may inhibit the pursuit of one's primary interests or preferred career goals (Lent, Brown and Hackett, 2002). This leads us to think that, at least to a certain degree, the 2008 financial crisis provided a favourable environment to the pursuit of majors whose pecuniary returns and job stability were somewhat seen as certain at that time.

Lent, Brown and Hackett (2002) hypothesized that when people perceive a need to compromise their interests because of limited opportunities, insurmountable barriers, or a non-supportive environment, their choices will be made primarily on the basis of job availability, self-efficacy beliefs, and outcome expectations. It is not only ability that drives a choice of major, but the entire surrounding a person finds herself in.

People help to construct their own career outcomes and their beliefs play key roles in this process; people are not merely beneficiaries (or victims) of intrapsychic, temperamental, or situational forces (Lent, Brown and Hackett, 2002). People are active agents, interacting with their environments and modifying them, and they are less likely to develop interests in career and academic pursuits for which they are otherwise well suited if they are not exposed to compelling learning opportunities that promote ability-congruent efficacy beliefs and positive outcome expectations (Lent, Brown and Hackett, 2002).

SCCT asserts that people form enduring interest in an activity when they view themselves as competent at it and when they anticipate that performing it will produce valued outcomes (Lent, Brown and Hackett, 2002). As exemplified by the two interest models pictured below, self-efficacy and outcome expectations regarding activity involvement exert an important, direct effect on the formation of career interests. Lent, Brown and Hackett (2002) formulated an affinity positive feedback mechanism: as people develop an affinity for an activity at which they feel efficacious and expect positive outcomes, they form goals for sustaining or increasing their involvement in that activity; these goals, in turn, increase the likelihood of engaging in the activity (Lent, Brown and Hackett, 2002).

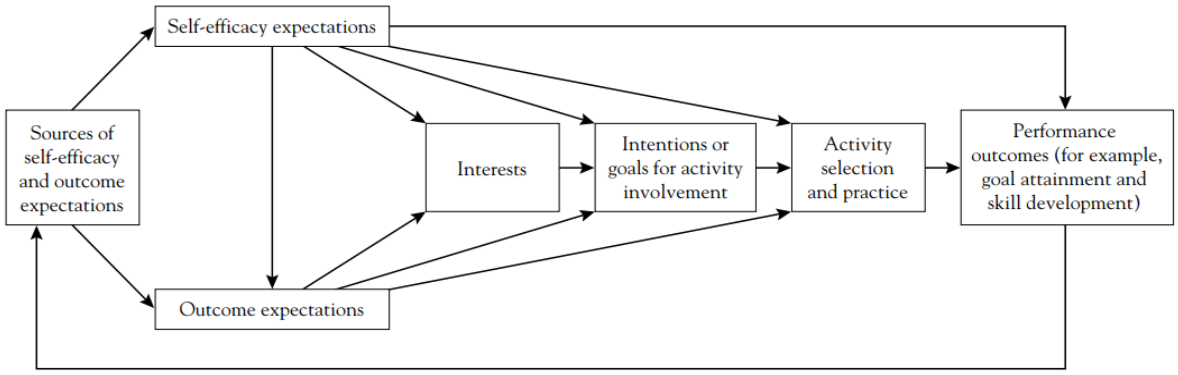
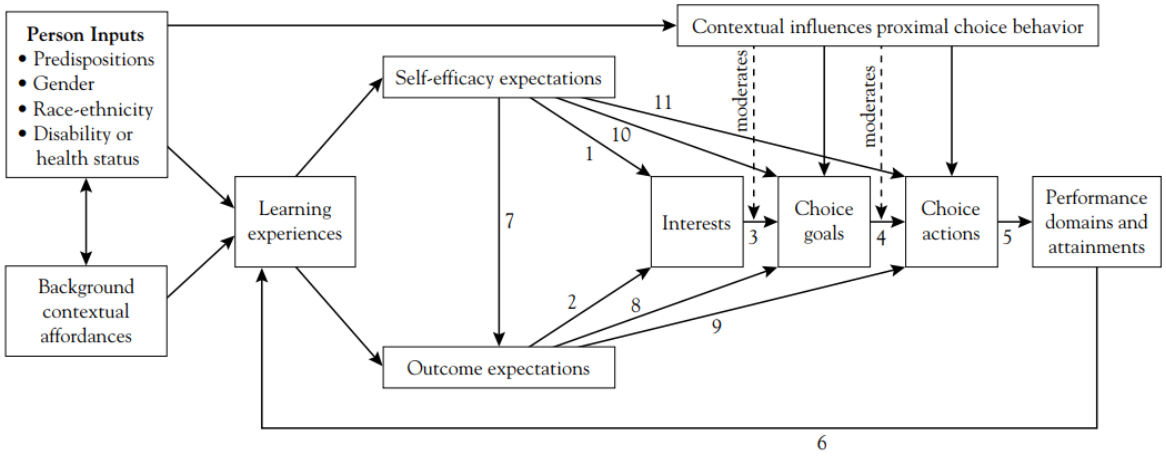


Figure 1 - Model of How Basic Career Interests Develop Over Time



Note: Direct relations between variables are indicated with solid lines; moderator effects (where a given variable strengthens or weakens the relations between two other variables) are shown with dashed lines.

Source: Copyright © 1993 by R. W. Lent, S. D. Brown, and G. Hackett. Reprinted by permission.

Figure 2 - Model of Person, Contextual, and Experiential Factors Affecting Career-Related Choice Behaviour

Figure 1 provides an overview of how selected person, contextual, and learning-experiential variables are hypothesized to influence both the social cognitive variables and subsequent career development outcomes, and Figure 2 shows that career choice goals and actions may be influenced directly by self-efficacy and outcome expectations (Lent, Brown and Hackett, 2002). The relationship of these two models reflects the developmental continuity between the evolution of basic vocational interests and their eventual translation into career-relevant choices (Lent, Brown and Hackett, 2002).

Making use of SCCT as a framework for improvements in education can be fruitful. Depending on what environment educators, policy makers, students and their families find themselves into, there can be a number of targets at which educational and career programs can be directed in order to facilitate for better future outcomes. It is undeniable that efforts to expand interests and nurture career aspirations in children and adolescents is vital for the progress of society and its members. But not only that, SCCT also can be used to promote successful work adjustment (e.g., satisfaction, performance) in adult workers (Lent, Brown and Hackett, 2002).

Career choice development is complex, and the decisions adolescents make rely on processing a wide range of interacting information (Rogers and Creed, 2011). STEM careers are well known to bring substantial private and social pecuniary returns (Altonji et al., 2016; Grossmann et al., 2016; Altonji and Zimmerman, 2017). At what extent do Irish students

form their career expectations based on both perceived and factual financial returns, and how did the 2008 financial crisis affect the pursuit of STEM careers by students sitting their Leaving Certificate is what I intend to help to elucidate with this study.

2.6 The Leaving Certificate

First introduced in 1924, the Leaving Certificate exam is the main door through which students leave secondary education and enter higher-level education in Ireland. This assessment tool is presented in three formats (or programmes) according to the student's goal: Established Leaving Certificate (the most common), Leaving Certificate Vocational Programme (the most practical, hands-on), and Leaving Certificate Applied (aimed at students who do not wish to proceed directly, or at all, to third level education). These programmes differ in outcomes and were designed to fit Ireland's youth's many needs.

In this study I chose to focus on the Established Leaving Certificate. For students over the age of sixteen, education is not mandatory in Ireland, being the Junior Certificate the last compulsory exam (by the end of a student's Junior Cycle) required by the State. After finishing the Junior Cycle, most students will continue to the Senior Cycle, a two-year programme which includes an optional Transition Year (which follows immediately after the Junior Cycle). What students studied during the Junior Cycle and what subjects they sat at the Junior Certificate indicate what they will choose to study during their Senior Cycle and, consequently, the subjects they will choose sit at their Leaving Certificate. Subjects are usually studied at either Ordinary or Higher Level, with Irish and Mathematics also being studied at Foundation Level.

For their Senior Cycle, students can choose to study from a list of thirty four subjects (depending on what their school has to offer) which are divided in five groups: Languages, Science, Business studies, Applied science, and Social studies. Students can choose to study between 6 and 8 subjects, being Irish, Mathematics and English mandatory (with a few exceptions). This leaves room for them to focus on subjects from the other groups.

For students who wish to enter a STEM-related course, it is necessary to sit at least one Science subject, which does not require to be related to the course envisioned (e.g. sitting

Physics and applying for Biotechnology), although each third-level institution in Ireland has different subjects and grade requirements for each course.

In 2017, a new grading scheme for the Leaving Certificate was introduced. Grades vary on a scale from one (highest) to eight (lowest). Marks between 100% to 30% are divided into seven grade bands with each band being 10% wide. Higher and Ordinary level grades one (H1 and O1 respectively) account for a percentage between 90 and 100; Higher and Ordinary level grades two (H2 and O2 respectively) account for a percentage between 80 and 90, and this way consecutively with the last grades being Higher and Ordinary level eight (H8 and O8 respectively), which accounts for a percentage between zero and 30 (see table below[1]).

New Grades and Common Points Scale for Leaving Certificate 2017			
Grade (%)	**Points**	**Grade (%)**	**Points**
H1 (90-100)	100		
H2 (80<90)	88		
H3 (70<80)	77		
H4 (60<70)	66		
H5 (50<60)	56	O1 (90-100)	56
H6 (40<50)	46	O2 (80<90)	46
H7 (30<40)	37	O3 (70<80)	37
H8 (0<30)	0	O4 (60<70)	28
		O5 (50<60)	20
		O6 (40<50)	12
		O7 (30<40)	0
		O8 (0<30)	0

Leaving Certificate Grades and Points Scale

3 Methodology

3.1 Introduction

[1] NEW COMMON POINTS SCALE FOR ENTRY INTO HIGHER EDUCATION FROM 2017. Retrieved from http://transition.ie/files/2015/Leaflet%20for%20Students%20-%20Revised%20Common%20Points%20Scale.pdf

Upon reading previous works in the areas of labour market, choice of college major, subjective expectations, returns to education and human capital, I narrowed down a couple of research methodologies that appeared the most on those works: descriptive quantitative research study and focus group. If combined together, these two methodologies would result in a mixed methodology. Although strong, applying this methodology to a study would require a long period of time from my part and the selected participants' part. It also would be a strenuous challenge to gather participants since most students who sat their Leaving Certificate exams in 2007 and 2008 are no longer in college and/or involved in the academic life. This would impact findings greatly as people's memories have their own biases (Klaaren et al., 1994). Therefore inquiring them about an event which happened ten years ago would not produce reliable results. Aware of this, I decided, then, to pursue an extensive quantitative method of data collection and analysis.

I chose this non-experimental research method because it is often an important and appropriate mode of research in education (Johnson, 2001), and it suited well the available data. Due to the nature of the methodology, direct causality could have not been inferred as there are many factors which can impact a student's career choice. Therefore this research had only a correlational aspect to it.

3.2 Data sources

3.2.1 Results

I searched for data that would best represent the case for the Leaving Certificate STEM subjects prior to the financial crisis to the present day. The primary sources of data for this study were the Annual Statistical Reports made available by the Department of Education and Skills (DES) on their website[2], which are linked to a database of statistics on the Central Statistics Office (CSO) website[3]. Sometimes they are presented in a .pdf format and sometimes in a .xls format, which can be tricky in terms of consistency since one expects to find tables easily and in the same order every year.

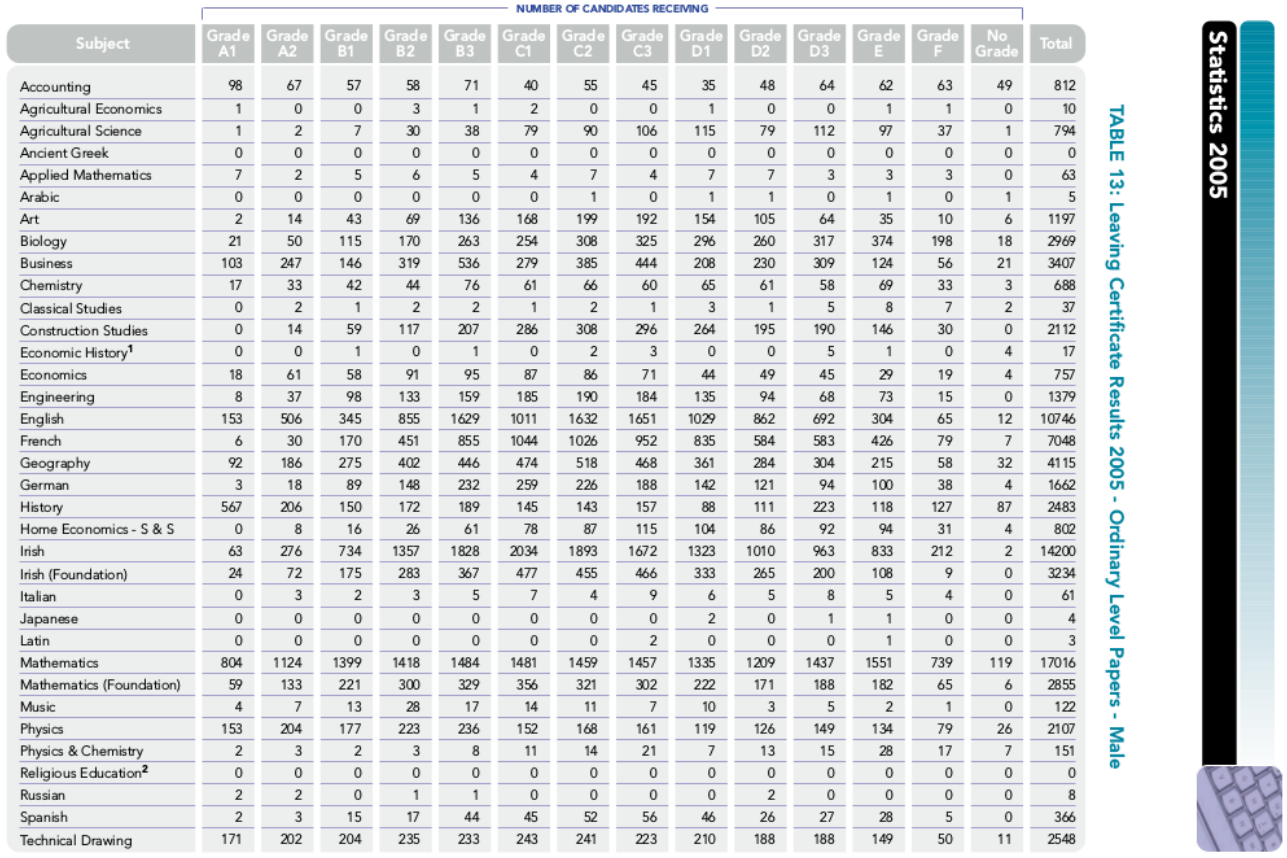
[2] Retrieved from https://www.education.ie/en/Publications/Statistics/Statistical-Reports/

[3] Retrieved from https://www.examinations.ie/statistics/

Annual statistical reports from 1993 to 2007 are available in .pdf format on the aforementioned Department of Education and Skills website, and from 2007 to 2015 on the State Examinations Commision website[4]. The Department of Education and Skills also offers statistical reports in .xlsx format from 2008 to 2018.

From 1993 to 2002, the statistical reports displayed a similar pattern: first it was presented the tables for General Education Statistics, then the tables containing the numbers for Primary Education came, followed by the tables for Secondary Education. The subsequent sections were not utilized in this study, but they are interesting nonetheless.

From 2003 to 2015, the statistical reports dealt mostly with financial and evaluative aspects of education and learning, reserving the appendix for the tables which were in part used in this study.



Statistics 2005

TABLE 13: Leaving Certificate Results 2005 - Ordinary Level Papers - Male

	NUMBER OF CANDIDATES RECEIVING														
Subject	Grade A1	Grade A2	Grade B1	Grade B2	Grade B3	Grade C1	Grade C2	Grade C3	Grade D1	Grade D2	Grade D3	Grade E	Grade F	No Grade	Total
Accounting	98	67	57	58	71	40	55	45	35	48	64	62	63	49	812
Agricultural Economics	1	0	0	3	1	2	0	0	1	0	0	1	1	0	10
Agricultural Science	1	2	7	30	38	79	90	106	115	79	112	97	37	1	794
Ancient Greek	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Applied Mathematics	7	2	5	6	5	4	7	4	7	7	3	3	3	0	63
Arabic	0	0	0	0	0	0	1	0	1	1	0	1	0	1	5
Art	2	14	43	69	136	168	199	192	154	105	64	35	10	6	1197
Biology	21	50	115	170	263	254	308	325	296	260	317	374	198	18	2969
Business	103	247	146	319	536	279	385	444	208	230	309	124	56	21	3407
Chemistry	17	33	42	44	76	61	66	60	65	61	58	69	33	3	688
Classical Studies	0	2	1	2	2	1	2	1	3	1	5	8	7	2	37
Construction Studies	0	14	59	117	207	286	308	296	264	195	190	146	30	0	2112
Economic History[1]	0	0	1	0	1	0	2	3	0	0	5	1	0	4	17
Economics	18	61	58	91	95	87	86	71	44	49	45	29	19	4	757
Engineering	8	37	98	133	159	185	190	184	135	94	68	73	15	0	1379
English	153	506	345	855	1629	1011	1632	1651	1029	862	692	304	65	12	10746
French	6	30	170	451	855	1044	1026	952	835	584	583	426	79	7	7048
Geography	92	186	275	402	446	474	518	468	361	284	304	215	58	32	4115
German	3	18	89	148	232	259	226	188	142	121	94	100	38	4	1662
History	567	206	150	172	189	145	143	157	88	111	223	118	127	87	2483
Home Economics - S & S	0	8	16	26	61	78	87	115	104	86	92	94	31	4	802
Irish	63	276	734	1357	1828	2034	1893	1672	1323	1010	963	833	212	2	14200
Irish (Foundation)	24	72	175	283	367	477	455	466	333	265	200	108	9	0	3234
Italian	0	3	2	3	5	7	4	9	6	5	8	5	4	0	61
Japanese	0	0	0	0	0	0	0	0	2	0	1	1	0	0	4
Latin	0	0	0	0	0	0	0	2	0	0	0	1	0	0	3
Mathematics	804	1124	1399	1418	1484	1481	1459	1457	1335	1209	1437	1551	739	119	17016
Mathematics (Foundation)	59	133	221	300	329	356	321	302	222	171	188	182	65	6	2855
Music	4	7	13	28	17	14	11	7	10	3	5	2	1	0	122
Physics	153	204	177	223	236	152	168	161	119	126	149	134	79	26	2107
Physics & Chemistry	2	3	2	3	8	11	14	21	7	13	15	28	17	7	151
Religious Education[2]	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Russian	2	2	0	1	1	0	0	0	0	2	0	0	0	0	8
Spanish	2	3	15	17	44	45	52	56	46	26	27	28	5	0	366
Technical Drawing	171	202	204	235	233	243	241	223	210	188	188	149	50	11	2548

Figure 3 - One of the tables containing data used in this study[5]

[4] Retrieved from https://www.examinations.ie/?l=en&mc=au&sc=pb

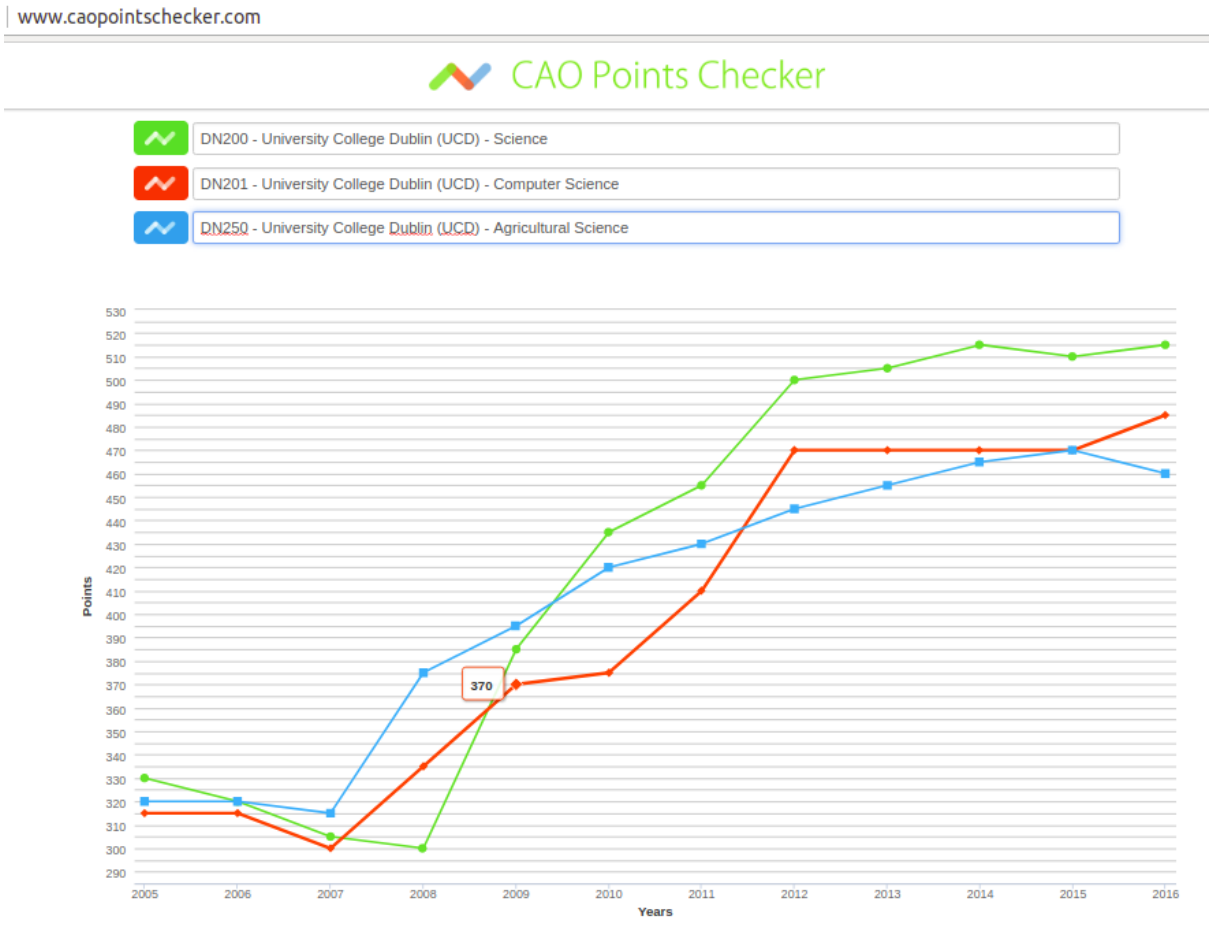
[5] Annual Statistical Report 2005, page 43. Retrieved from https://www.examinations.ie/about-us/060306Finalpdf.pdf.

3.2.2 Discussion

The Discussion chapter concerns the division between single-sex and mixed schools, the number of required points for entrance in STEM courses for each major university, and how both these variables changed throughout the years.

In order to plot the graphs related to these matters, I made use of the same Annual Statistical Reports, but collected data from a larger number of reports. Along with these resources, I also used the "CAO Points Checker", a website[6] which was developed in order to help students to foresee the necessary amounts of points required for their desired third-level courses in every third-level institution in Ireland.

Data for all the third-level courses only go back to 2005 and a significant number of STEM courses were created after the financial crisis, which rendered them unsuitable for this study.



[6] Retrieved from http://www.caopointschecker.com/

Figure 4 - A screenshot of the website CAO Points Checker showing STEM courses and their points' evolution throughout the years

3.3 Data compilation and limitations

After downloading all the annual statistical reports from 1993 to 2015 to my computer, I manually transferred a substantial part of their content to the program LibreOffice Calc, which is an open source spreadsheet software version of Microsoft Excel. Because I am familiar with open source programs, dealing with LibreOffice was not an issue, and the same results can be expected if choosing any other program that allows the creation of graphic as outputs.

I chose to end part of the research at the year 2015 due to non-existent data related to the number of students sitting the Leaving Certificate subjects post 2015, although certain graphs presented in the subsequent chapters (Results and Discussion) feature data for a longer period of time (e.g. data on the number of single-sex and mixed schools from 1993 to 2017).

This limitation was due to the absence of crucial data from the DES and the CSO, which might be corrected in the future. When inquired about it, both correspondents from each governmental body were eager to help in any way they could, sometimes pointing out to different materials and sections in their websites.

Each graph was designed on its own and based on a particular set of data, therefore the value of their independent variable "time" may change from graph to graph. There is consistency in the range of value when comparing independent variables within the same set of graphs (e.g. the number of students sitting Agricultural Science and the number of students sitting Chemistry versus the year), but the same may not happen when comparing the range of value of independent variables between different sets of graphs.

3.4 Graphs and analysis

3.4.1 Results

The objective of this study was to answer the question on if and how the 2008 financial crisis affected the number of students sitting STEM subjects at the Leaving Certificate exam. It was intuitive that I would have to compile the number of students, which are separated by gender (male and female) in the statistical reports, sitting every STEM subject throughout the years. For this I chose a set of subjects: Agricultural Science, Applied Mathematics, Biology, Chemistry, Engineering, Mathematics, Physics, and Physics and Chemistry.

For the first part of this study, every subject was analysed graphically from the years 1993 to 2015 as suggested by my supervisor Dr. Joseph Roche. Each graph represents a subject, and the number of students sitting every subject is plotted separately by gender and level (Ordinary and Higher), which resulted in a total of in six different lines per graph (male ordinary level, female ordinary level, total ordinary level, male higher level, female higher level and total higher level) per subject.

Almost the same process was repeated for the percentage of students sitting the previously mentioned STEM subjects compared to the overall number of pupils sitting the Leaving Certificate exam every year from 1993 to 2015. This time only the numbers of male, female and total students were considered. To get to the percentage, I took the number of male students sitting Biology, for example, and divided it by the total number of males sitting the Leaving Certificate exam for every year considered and then multiplied the result by 100. This approach was chosen in order to shred a light on the proportion of students sitting STEM subjects in comparison to the overall number of students who sat the Leaving Certificate exam.

The last part of the graphs represents a breakdown between genders at the Higher Level of STEM subjects. It follows the same procedure of the first part, but the design of the graphs changes in order to allow for a clear representation of the schism between genders. The number of male and female students sitting each subject is plotted against the years (which values range from 1993 to 2015), and the resulted graphs echoes similar findings that will be cited and discussed on the Discussion chapter.

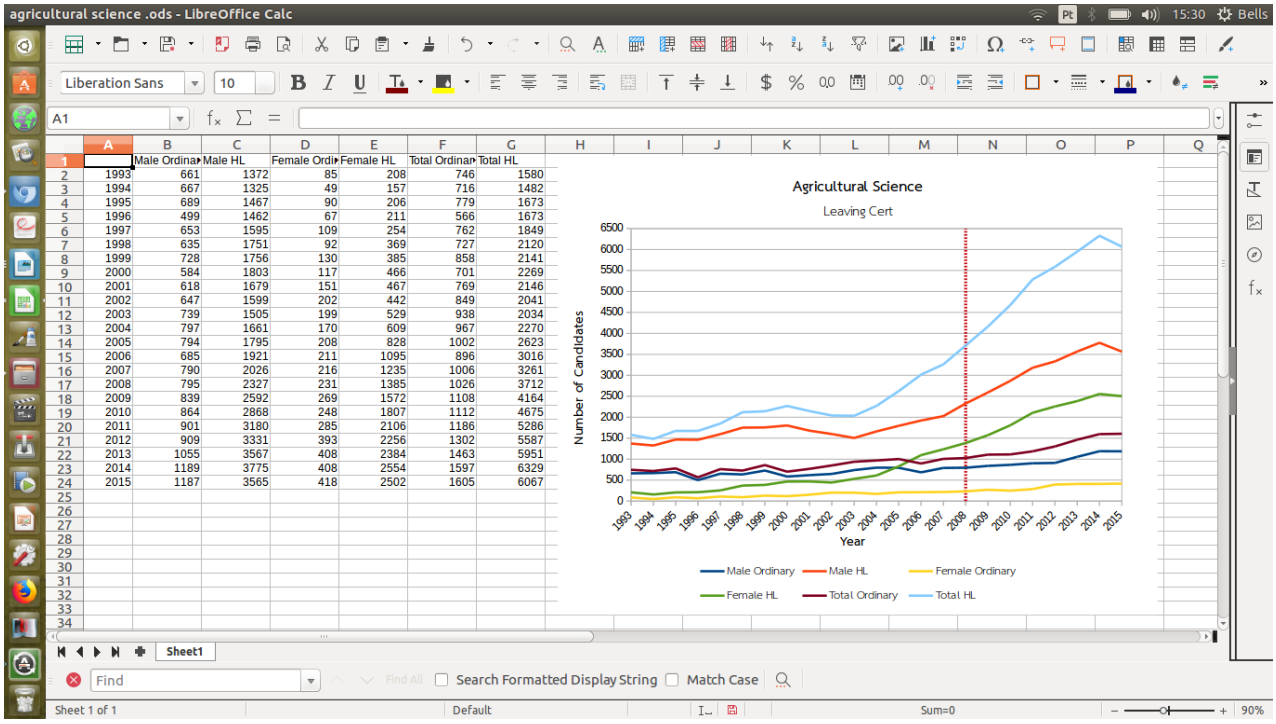


Figure 5 - A screenshot showing how the data was plotted using the software LibreOffice calc

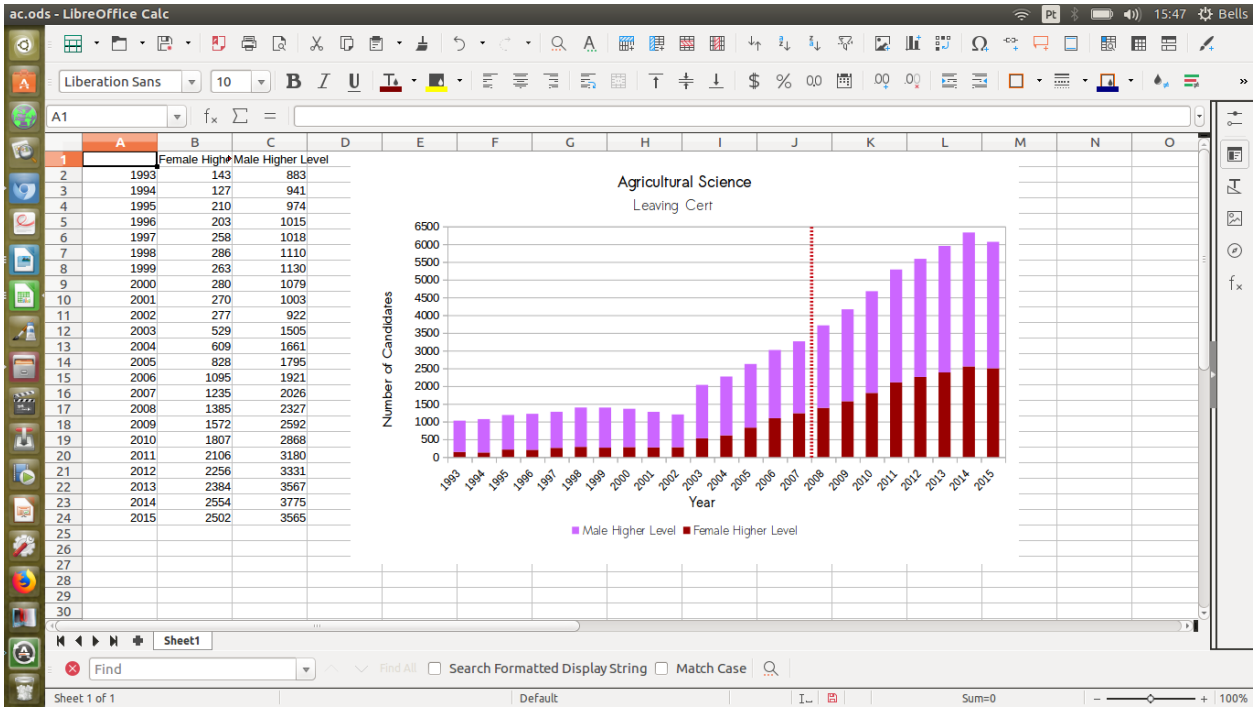


Figure 6 - A screenshot showing how the data was plotted using the software LibreOffice calc

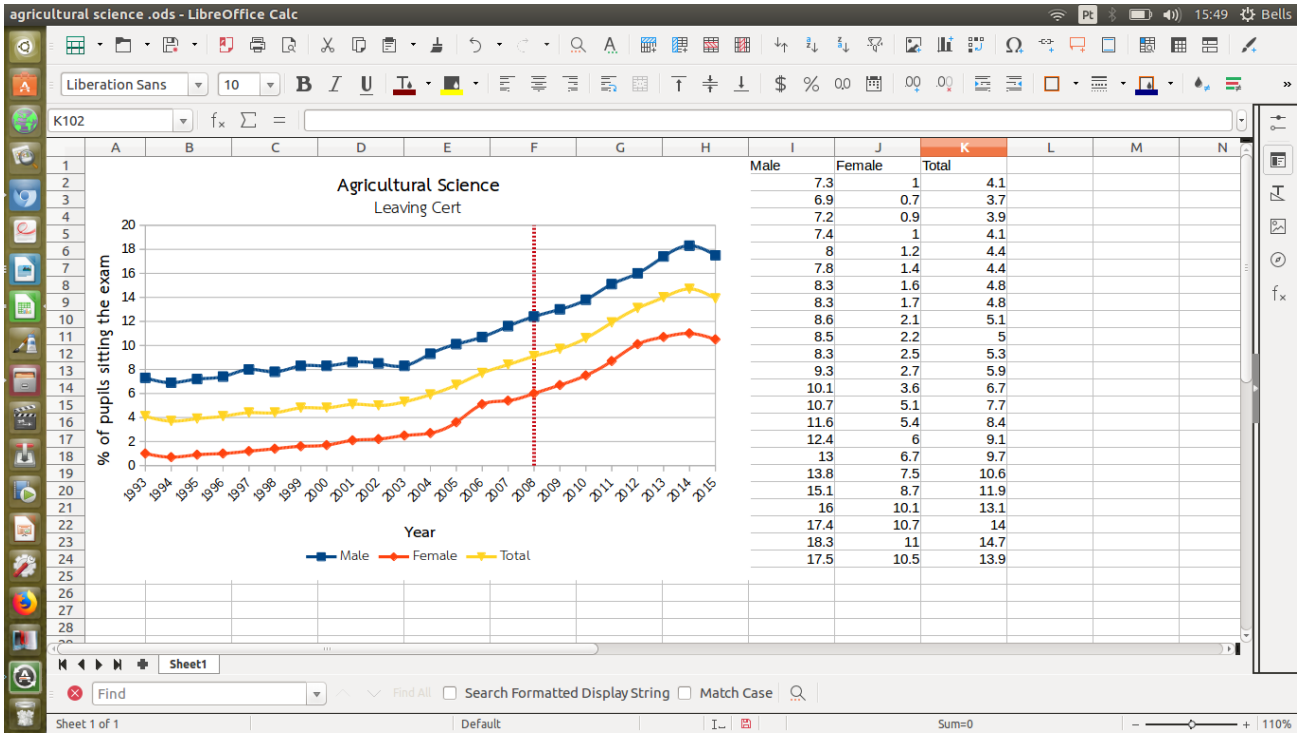


Figure 7 - A screenshot showing how the data was plotted using the software LibreOffice calc

3.4.2 Discussion

Due to questionings which arose from the results found and presented in this study, there was a necessity to further the understanding of those results. I decided to take a deeper look at the Annual Statistical Reports and to select data related to single-sex and mixed schools. This decision was followed by the same procedure for data collection, and employed in graph plotting using LibreOffice Calc techniques.

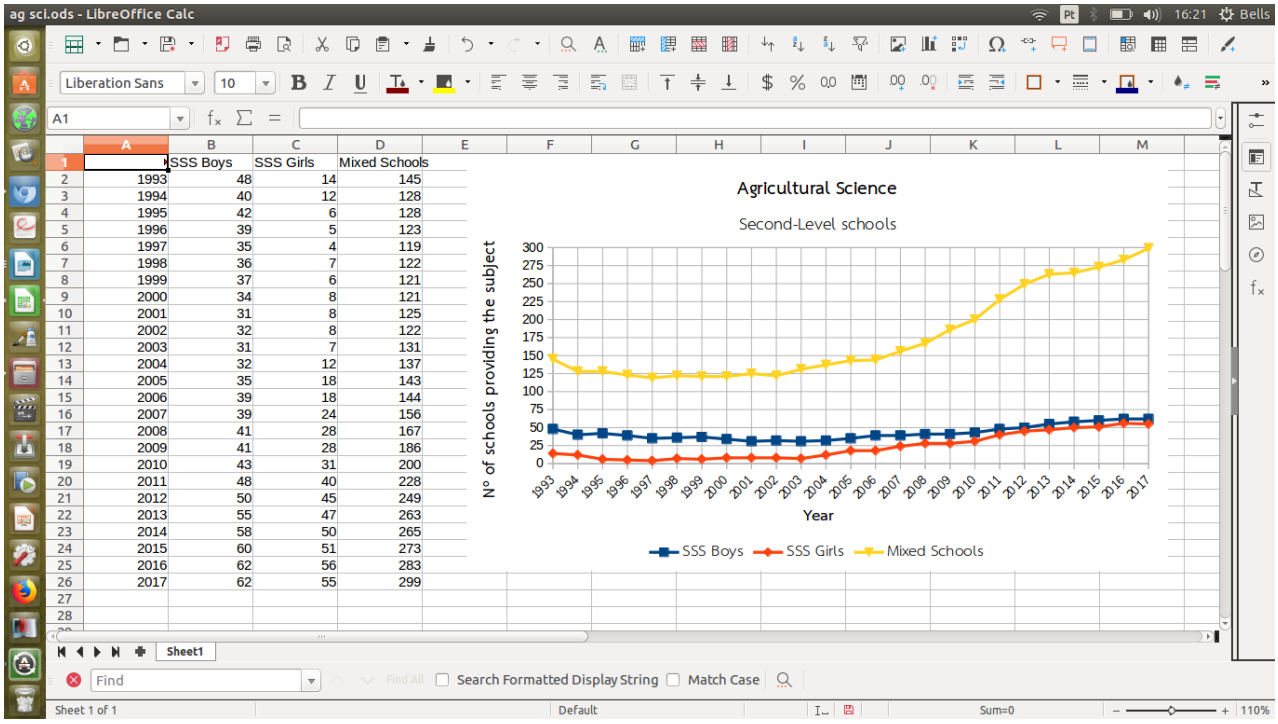


Figure 8 - A screenshot showing how the data was plotted using the software LibreOffice calc

I also made use of data available on the website CAO Points Checker by transferring this data to the LibreOffice Calc software and then following the same procedure of graph plotting I did for all the other graphs presented in this study.

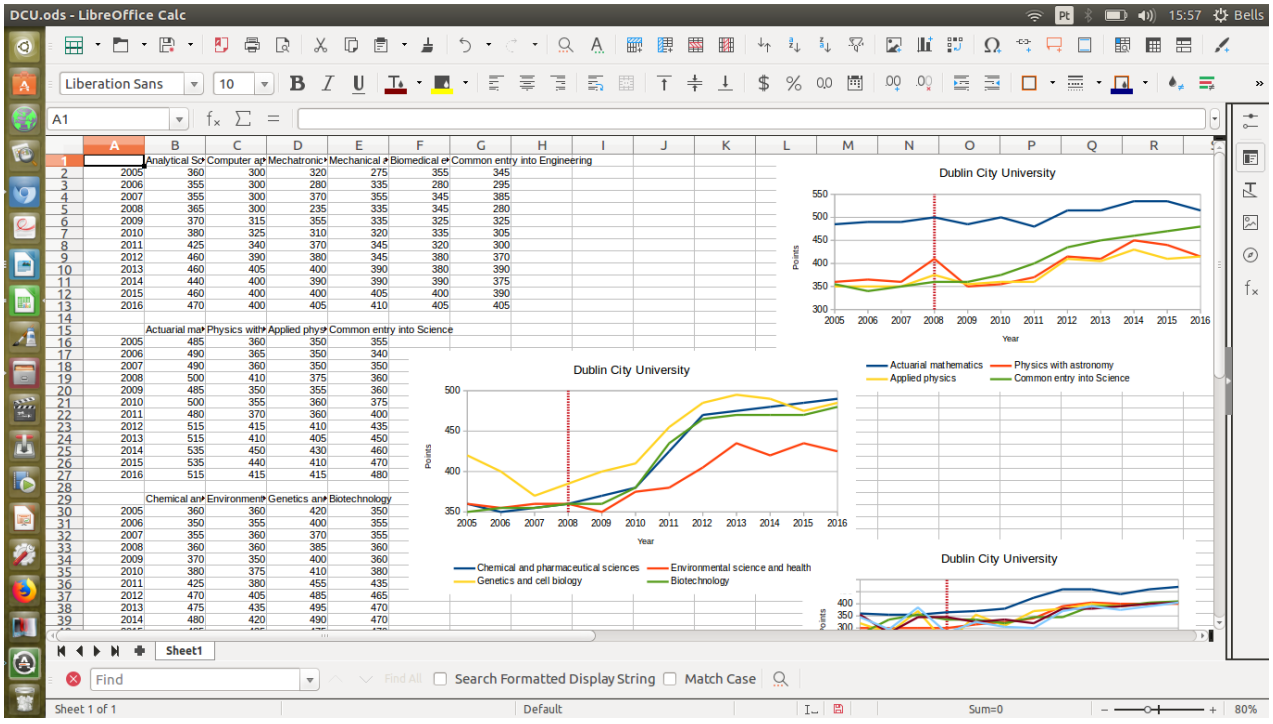


Figure 9 - A screenshot showing how the data was plotted using the software LibreOffice calc

Both the data selected for this study and the LibreOffice Calc software are available for download online, free of charge. All the statistics used in this study are public domain.

4 Research Findings

4.1 Introduction

These results aim to answer the question of how the 2008 financial crisis affected the pursuit of STEM subjects by students sitting the Leaving Certificate. The Leaving Certificate exam is considered an inflection point for students since it accounts for the entrance to third-level institutions in the Republic of Ireland. I hope to shed a light on its evolution throughout the years in order to evaluate the importance students place on STEM subjects and, consequently, future STEM careers.

4.2 STEM Leaving Certificate subjects

4.2.1 Agricultural Science

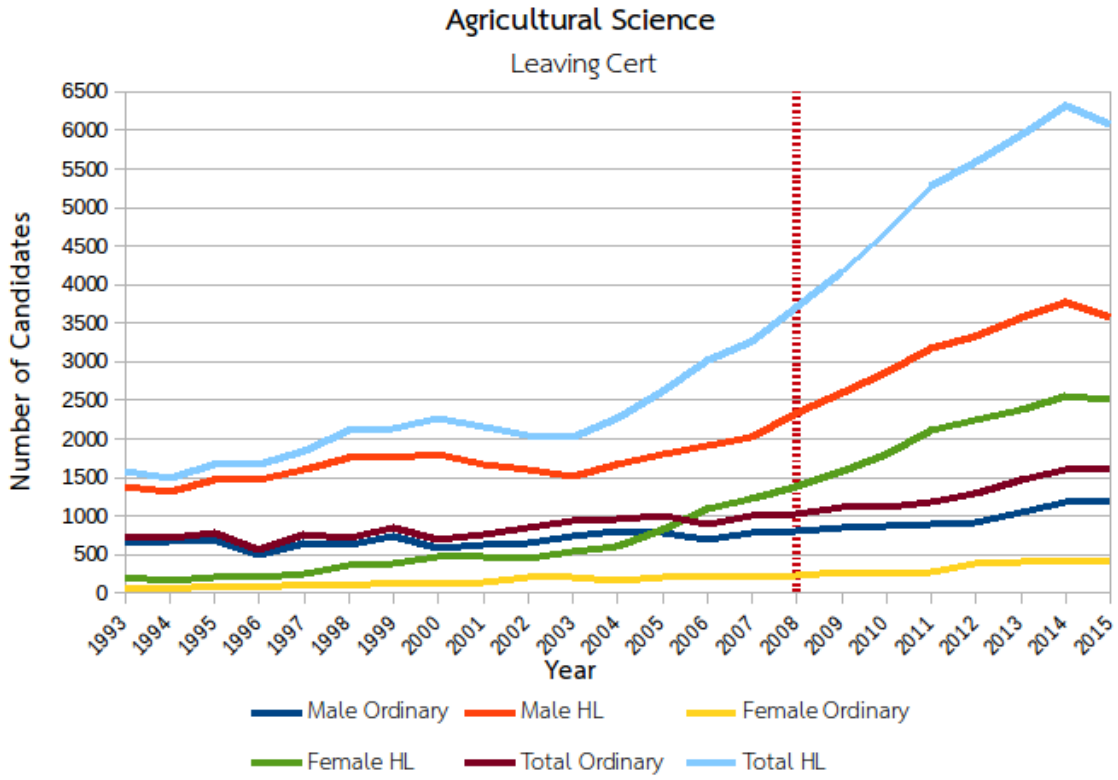


Figure 10 - Agricultural Science

Agricultural science is a subject assessed at two levels, Ordinary Level and Higher Level, through assessment work and a written examination, both undertaken during the course. As pictured in Figure 10, the subject has been steadily seeing an increase in the numbers of candidates since around 2003. More males and females are choosing to sit the Higher Level order of the exam, driving the total amount to reach an all-time peak in 2014 with 6329 pupils, 3775 males and 2554 females.

If compared to the numbers observed in 1994, a twenty year difference in time resulted in an approximately two point eight five times increase in demand for the subject for the Higher Level order for males - in 1994 the amount of male pupils was 1325 – and a sixteen point twenty seven increase in demand for females – in 1994, the amount of female pupils choosing to sit Higher Level order exam was 157.

When taking into consideration the Ordinary Level, the amount of male and female pupils has increased in the twenty two years period considered, but both quantities have always been lower than their Higher Level gender counterparts.

No overlap has been observed or a switch between genders throughout the time-period considered for Ordinary and Higher levels, being the amount of male candidates always greater than the amount of females for both levels.

No substantial or acute change has been observed in the amount of candidates one year before and one year after the 2008 financial crisis hit Ireland, which weakens the proposed correlation between the later and the former observed events.

4.2.2 Applied Mathematics

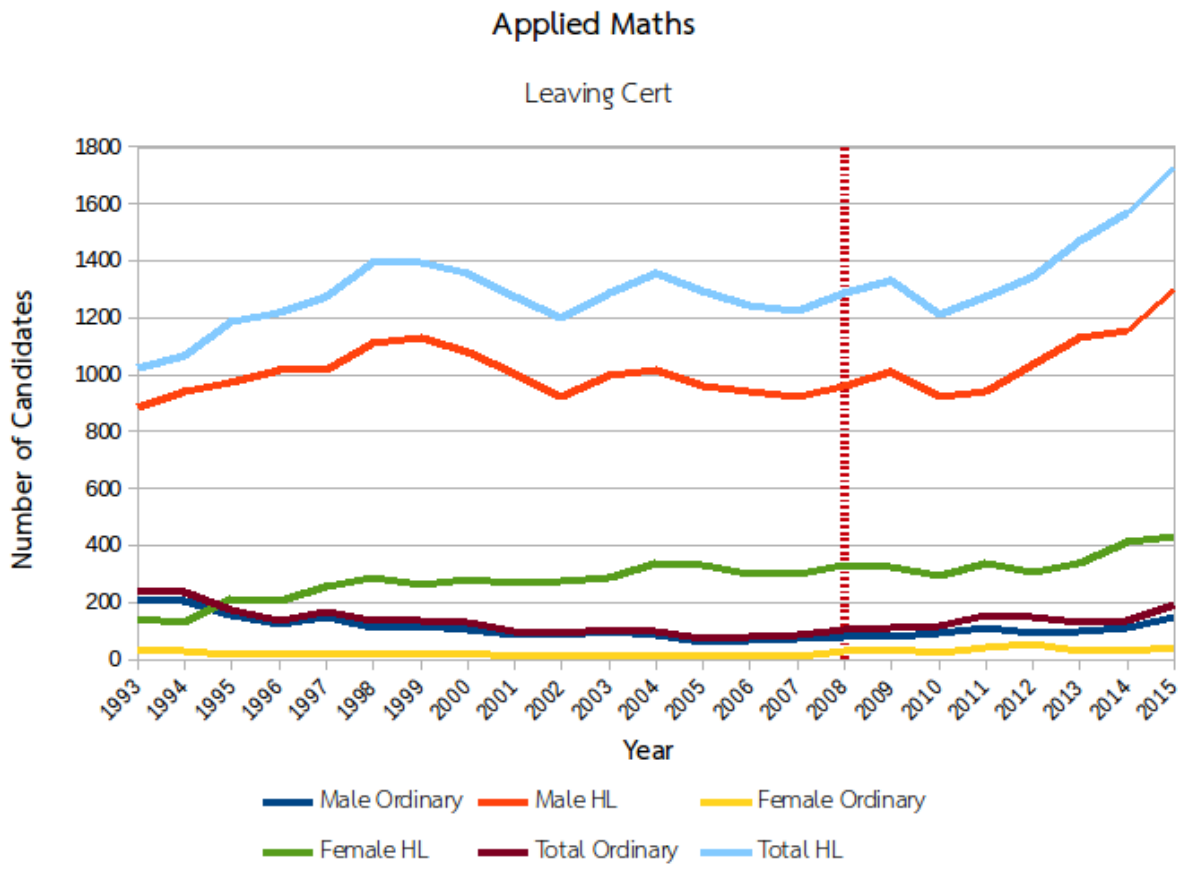


Figure 11 - Applied Mathematics

The subject Applied Mathematics (or Applied Maths), which is composed mostly of mathematics applied to physics, is, like all Leaving Certificate subjects, assessed at two levels: Ordinary Level and Higher Level. Figure 11 shows how the amount of candidates

choosing to sit both levels of the exam has changed from 1993 to 2015 for self-declared male and female candidates.

Considerably less sought when compared to all other subjects bar one, Applied Mathematics candidates make an interesting case: the gender disparity between male and female Higher Level candidates is blatantly perceived regardless of the year analysed.

In 1993, the ratio “male to female” at Ordinary level was approximately five, and six at Higher Level. In 2015, twenty two years later, the same ratio was approximately 3 at both Ordinary and Higher levels. Gender disparity has decreased throughout the years, just like the number of candidates sitting the Ordinary Level for both genders.

When considering the change in the amount of candidates sitting the Higher Level of the exam from 1993 to 2015, one can notice an increase of sixty eight percent in the number of male candidates and an increase of two hundred and two percent in the number of female candidates.

A substantial inflexion point can be observed in 2010 for males sitting the Higher Level exam, which follows a 5-year constant rate-growth, but no noteworthy change for both levels and genders can be seen at the 2008 mark.

4.2.3 Biology

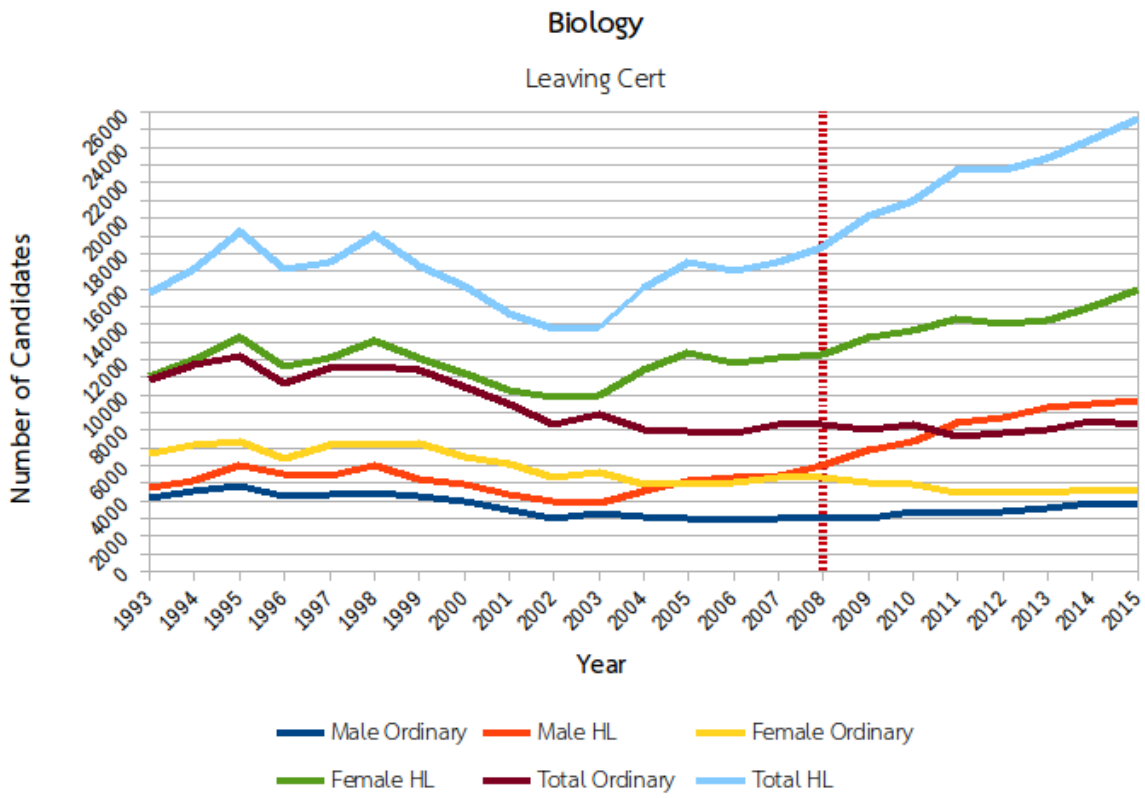


Figure 12 - Biology

The results so far have shown a higher number of males sitting Higher Level exams for Applied Mathematics and Agricultural Science when compared to their female counterparts for every year considered.

For Biology, although female candidates outnumbered males in both levels every year, at least for the first half-part of the time-period considered as observed in Figure 12. From 1993 to 2004, there has been no significant change (number of candidates > 2000) in the number of females and males sitting the Ordinary Level, but the pace of female candidates has been steadily decreasing throughout the years.

When considering the Higher Level exam, the number of female candidates reached an all-time high in 2015 with almost 15910 female candidates choosing to sit Biology for their Leaving Certificate, 4884 more than the Higher Level amount in 1993, which represents an increase of forty four percent in the number.

It is worth highlighting the fact there has been a considerable rise in the number of male Higher Level candidates starting in 2007 and progressing until 2015. The number of male candidates increased from 5441 in 2007 to 9685 in 2015, which represents a growth of seventy eight percent. Since Biology is a requirement for most healthcare-related college courses (such as dentistry, nursery and medicine), such substantial growth may indicate an awareness of economic instability, which reflects a demand for jobs that suffer the least from the effects of the recession on the labour market (Kopelman and Roses, 2016; Dolfman and Holden, 2018).

4.2.4 Chemistry

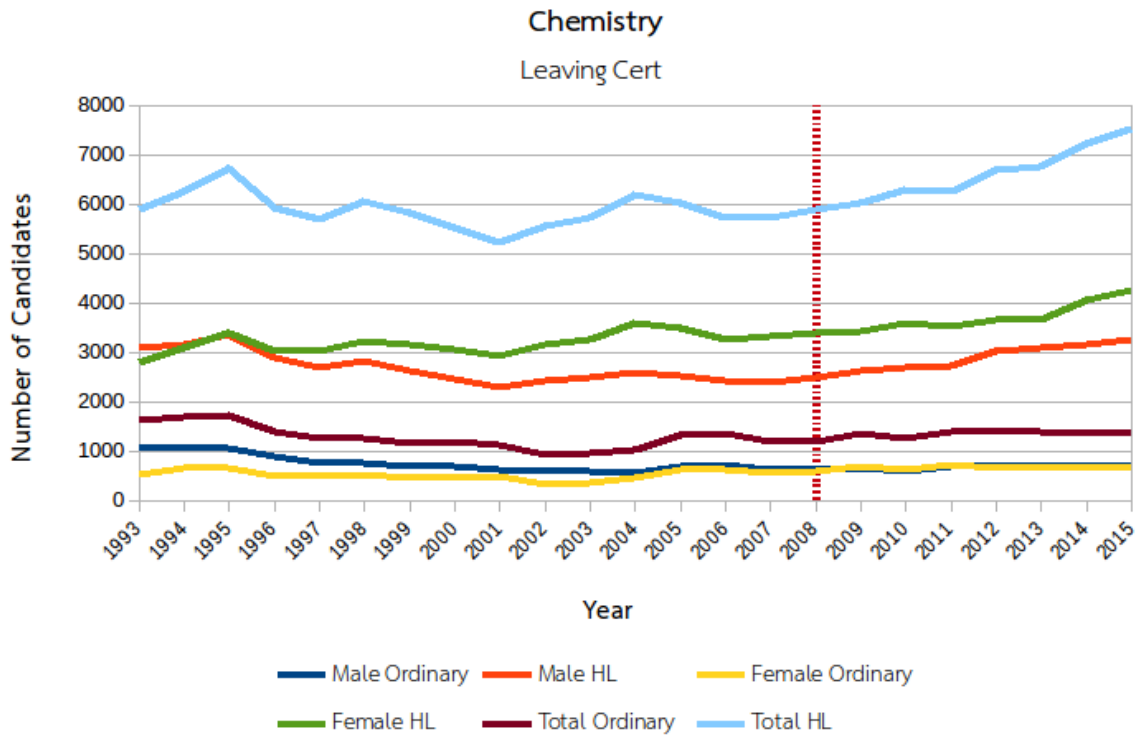


Figure 13 - Chemistry

As Figure 13 shows, the results for Chemistry revealed a minor difference between the candidates' genders. At the Ordinary Level, the amount of male candidates is similar to the amount of female candidates during the last half-part of the time-period considered. Females started in fewer numbers compared to males and from 1993 to 2004 the gap between them has been narrowing until both reached very similar quantities in 2008.

At the Higher Level, females have been outnumbering males since both genders reached a peak in 1995. From 2001 onwards, there has been a steady and increasing rate in the number of both female and male candidates, reaching their high in 2015 with 3276 male candidates and 4256 female candidates.

No drastic shift occurred in 2008. The only substantial change in numbers worth mentioning is the increase in female candidates at the Higher Level when considering the period from 1993 to 2015, which was fifty three percent (from 2780 candidates in 1993 to 4257 candidates in 2015).

4.2.5 Engineering

Since the beginning of the time-period considered, the number of male candidates sitting the Engineering exam has been staggering greater than the number of female candidates sitting the same exam (Figure 14). Such disparity is indicative of the low number of females enrolling in engineering-related courses in Irish Universities and Technology Institutes, and a reason to be concerned when predicting the labour market's future overall (Reuben, Wiswall and Zafar, 2017).

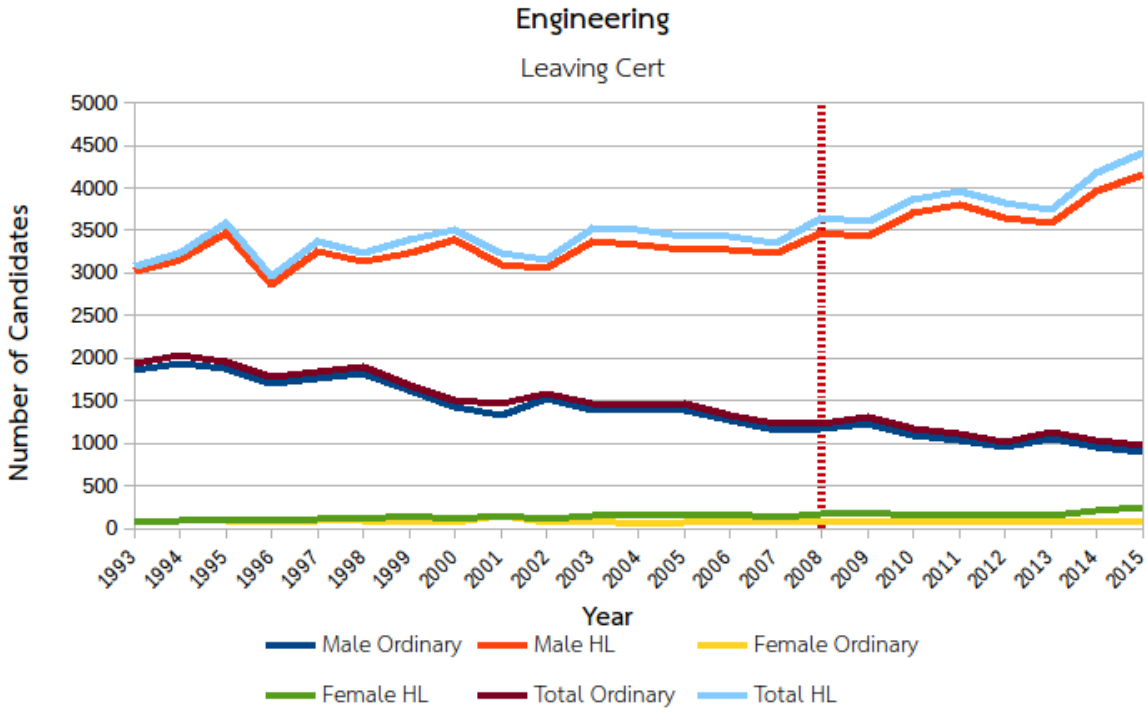


Figure 14 - Engineering

The number of males choosing to sit the Ordinary Level has practically halved in twenty two years, going from 1886 in 1993 to mere 893 candidates in 2015. Conversely, the number of males sitting the Higher Level exam has gone from 3011 in 1993 to 4159 in 2015, a notable growth of thirty eight percent. The biggest change in numbers starts in 2007, 3228 candidates, and continues until 2015, the last year considered.

The Leaving Certificate Engineering exam consists of a written examination, a project and a practical examination. Most girl-only schools do not offer the necessary preparation for the exam, which might explain why most girls choose not to sit it. Further research in the area is advised, considering the increasing demand for engineers in the labour market and also to highlight a possible, and worrisomely disfavorable, gender-bias in second-level schools funded by the state.

4.2.6 Mathematics

Mathematics is the only STEM-related Leaving Certificate subject which can be examined at three levels - Higher, Ordinary and Foundation – and there are two examination papers at

each level. Due to being one of the three required subjects which students need to have at least a pass grade in to gain entry to any university in Ireland, the number of students choosing to sit Mathematics is very high.

In 2012 Irish Higher Education Institutions introduced the Bonus Points scheme for Higher Level Leaving Certificate Mathematics, which might explain why the number of candidates, both males and females, choosing to sit the Mathematics Higher Level exam has increased since 2011 (Figure 15). Concomitantly, Ordinary Level numbers have decreased, hitting all-time low points for both genders – 15949 male and 17317 female candidates.

Following the same path of Chemistry, no drastic change in numbers occurred in 2008.

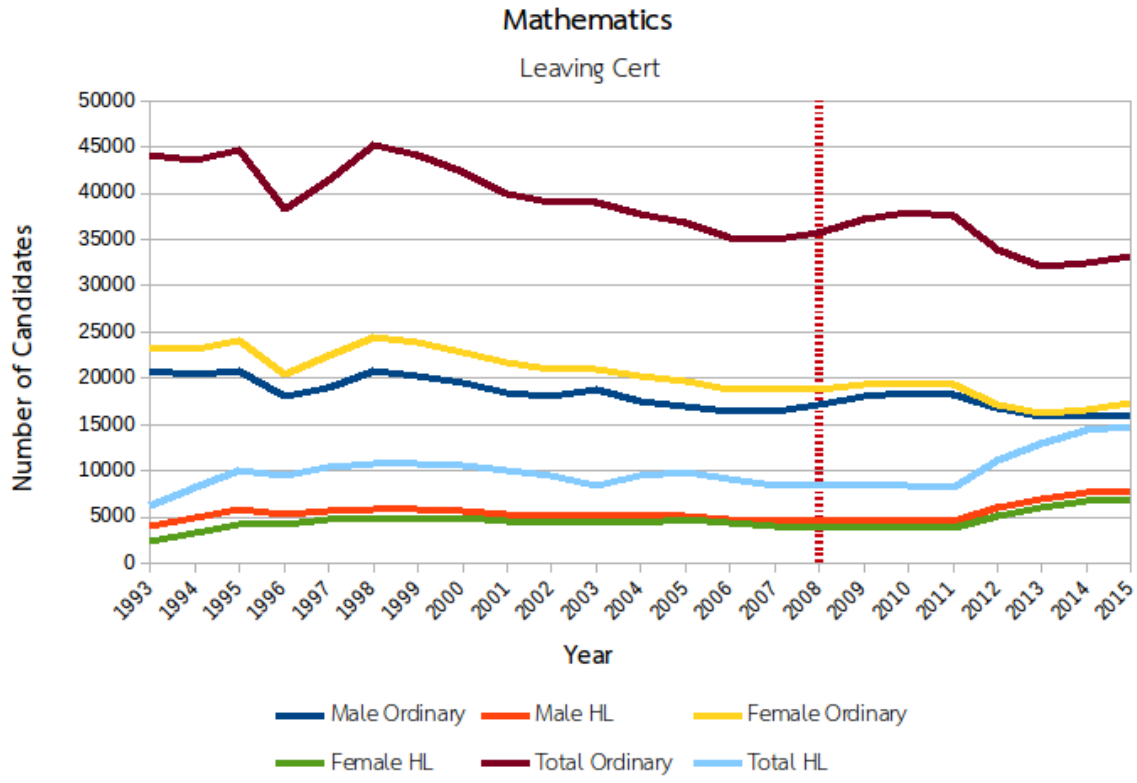


Figure 15 - Mathematics

4.2.7 Physics

The results for Physics (Figure 16) mimic, on a certain level, what has been seen previously in Engineering (Figure 14). Fewer females than males chose to sit the exam at both Ordinary and Higher Levels, and all numbers have decreased in the time-period considered.

In 1993, while 5046 male candidates chose Higher Level Physics, only 2134 female candidates did the same, a difference of one hundred and thirty six percent. In 2015, the difference between genders was one hundred and sixty eight percent (4196 males and 1568 females). For Ordinary Level Physics, the difference between the number of male and female candidates was even greater in 1993: while 3363 males decided to sit the exam, 531 females followed, which gives a ratio of more than six males for one female; the situation gets a bit narrower in 2015 with the ratio of four males to one female.

No significant change was noticed in the numbers related to the year 2008 for males and females at both levels.

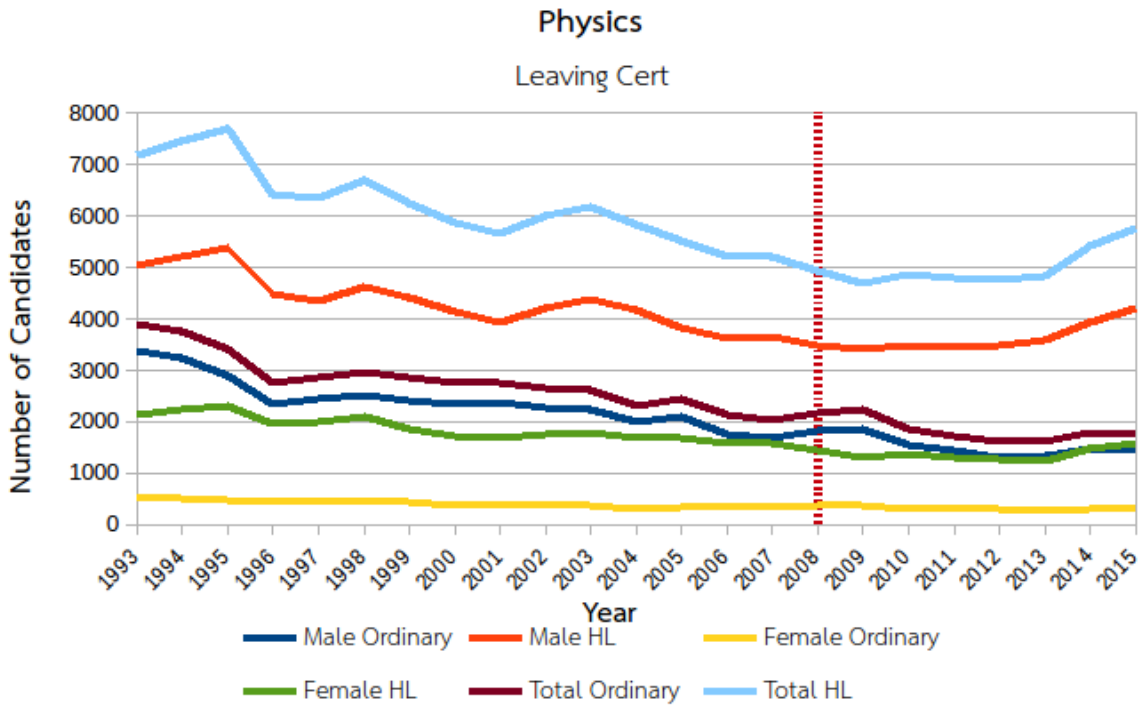


Figure 16 - Physics

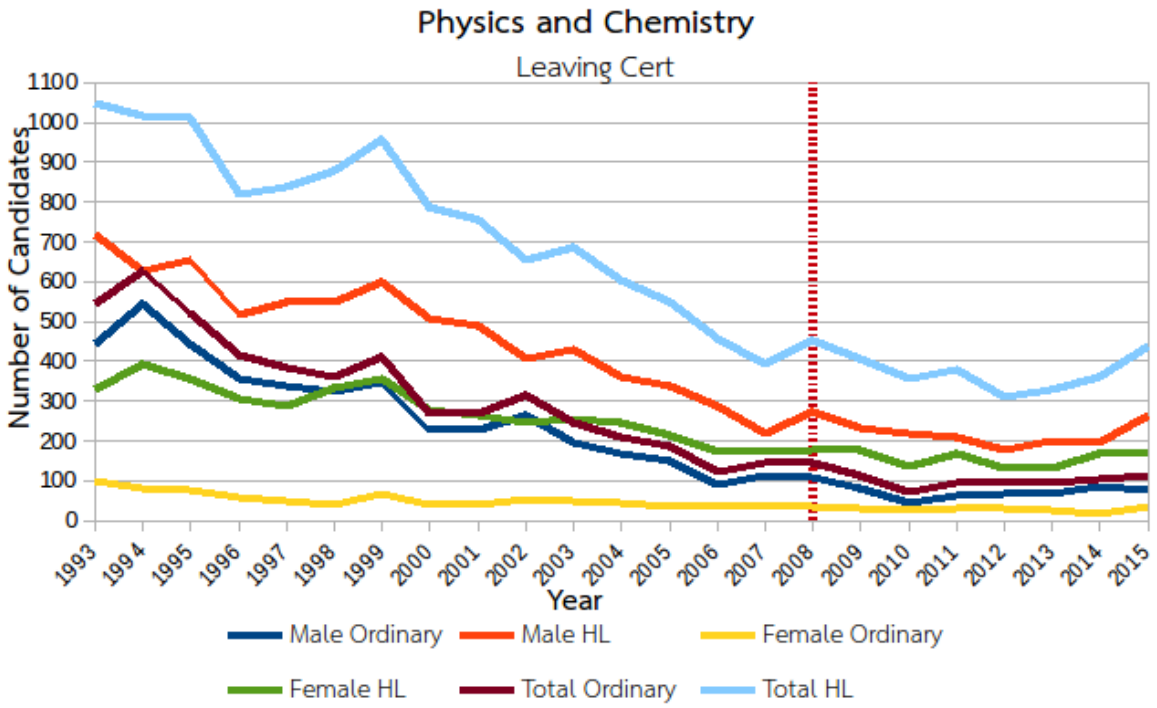


Figure 17 - Physics and Chemistry

4.2.8 Physics and Chemistry

One reason why the number of pupils sitting the Physics and Chemistry Leaving Certificate exam (Figure 17) has been drastically decreasing for the past twenty two years is that fewer schools are offering to teach the subject, and the fact that when a pupil sits Physics and Chemistry, she cannot sit Physics or Chemistry individually. Most STEM-related and healthcare college courses do not accept Physics and Chemistry points, requiring from the candidate good grades in Physics and/or Chemistry as separated subjects.

There was an astounding gap between the numbers of males sitting both Higher and Ordinary Levels in 1993 and 2015. At the beginning of this time-period, 443 male candidates sat at Ordinary Level and 717 at Higher Level; in 2015, for the aforementioned Levels, the numbers were 78 and 266. The change in the number of Ordinary Level male candidates from 1993 to 2015 is approximately minus four hundred and sixty eight percent, whilst at Higher Level is minus one hundred and seventy percent with the same twenty two years period considered.

In 1993, 100 females sat at Ordinary Level, while 330 pursued grades at Higher Level. In 2015, there were 37 at Ordinary Level and 171 at Higher Level: a difference of minus one hundred and seventy percent and minus ninety three percent respectively.

No substantial change was noticed in 2008 for male and female candidates at both levels.

4.3 STEM Leaving Certificate subjects: overall comparison

Aiming to elucidate the variation in the pursuit of STEM subjects at the Leaving Certificate exam throughout the years, I chose to work with the percentage of pupils sitting the four main STEM subjects – Biology, Chemistry, Mathematics, and Physics – generally offered to both boys and girls, and plot their respective values in relation to every year the exam took place starting in 1993.

4.3.1 Male

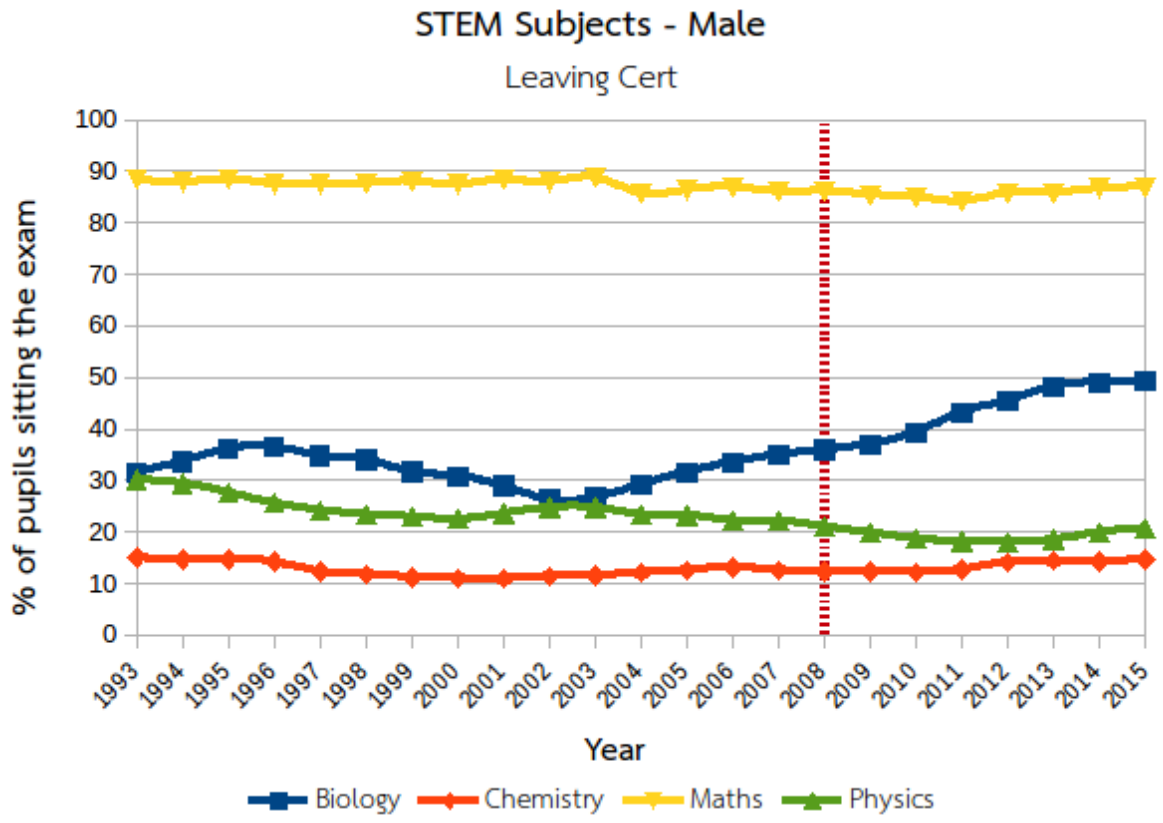


Figure 18 - STEM Subjects: Male

As exemplified in Figure 18, from 1993 to 2015, there was an overall small rate of variation in the percentage of male pupils sitting Mathematics, with its lowest point being eighty four point one percent in 2011 and its highest hitting eighty eight seven percent in 2003. The presented subject's relative stability, considering its numbers, can be attributed in part to its mandatory character when it comes to applications to Irish Higher Education institutions, which also might explain why it shows no drastic change at the 2008 mark.

The second most popular STEM subject at the Leaving Certificate is the same for both male (Figure 18) and female (Figure 19) candidates: Biology. Although presenting a considerable variation in numbers – from twenty six point two percent in 2002 to forty nine point three percent in 2015 - throughout the time-period considered, its prominent second-place superiority remained assured for twenty two years. In 2015, while almost half the number of males chose to sit Biology, only one fifth chose to sit Physics, a startling thirty percent difference. After experiencing a steady downfall in 2002, the subject has gained traction and has been increasing in numbers since then.

Both Physics and Chemistry suffered through almost the same variation changes, in module, from year to year. At the start of the time-period considered, thirty one percent of the male Leaving Certificate candidates chose to sit Physics, while fifteen percent chose Chemistry. The former hit its lowest percentage point in 2012 with eighteen percent, and ten point nine percent in 2001. After 1993, Physics' numbers never recovered and they have been in relative decline since 2003, with no significant schism in 2008. As regards to Chemistry, its ups and downs in numbers never reached a difference bigger than four percent, more or less. Since 2008, there's been a regular increase in male numbers, reaching almost its initial peak (fifteen percent in 1993) at fourteen point seven percent.

4.3.2 Female

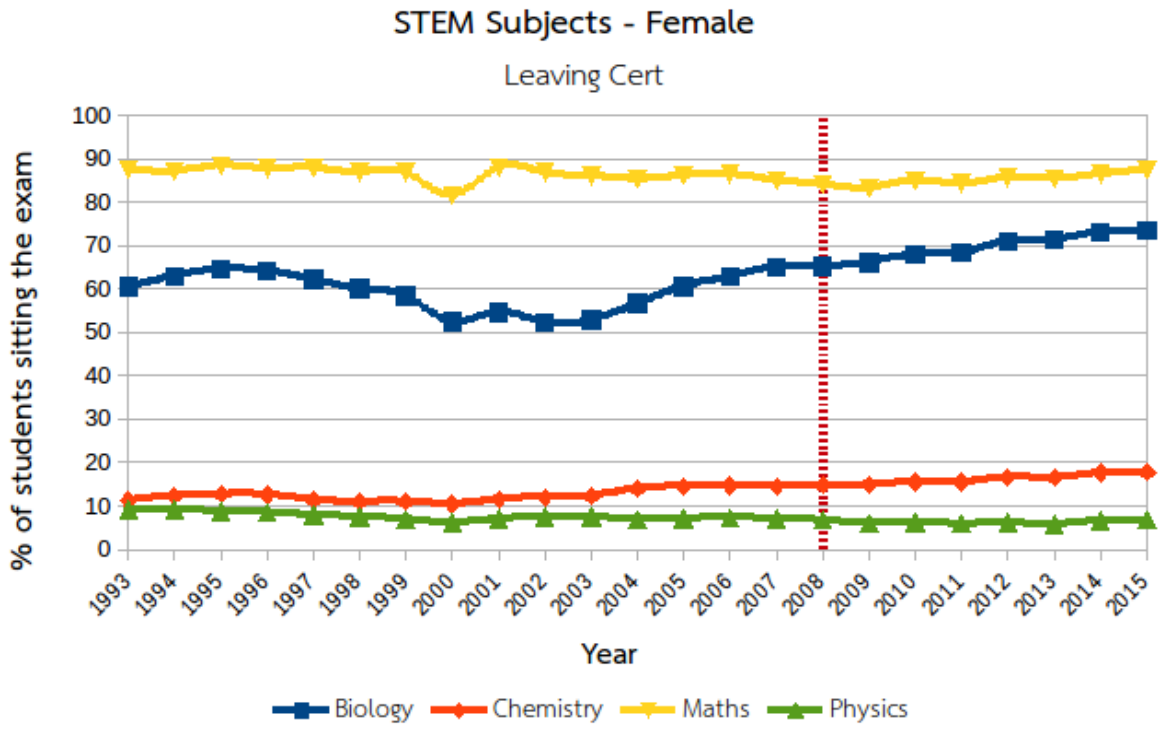


Figure 19 - STEM Subjects: Female

Insofar as our concern with numbers goes, female candidates are relatively more tied up to at least one STEM subject when compared to males, and it is Biology. The mandatory character of Mathematics also applies to females, which reflects similarly in Figure 19 as it did with males in Figure 18, so its effect does not collaborate to elucidate this study's hypothesis.

In regard to the other three STEM subjects, it is worth noting how Chemistry has a bigger pursuit when compared to Physics regardless of the year we analyse. They both started off at around ten percent in 1993 but have been diverging from each other since then. The biggest observed gap between them two occurred in 2015 with Chemistry being chosen by seventeen point eight percent of female candidates and Physics being picked up by six point seven percent of the female Leaving Certificate population. This equals to an eleven point one percent difference in numbers, which makes it for one fifth of the difference between Chemistry and Biology candidates in 2015 – and a difference of sixty six point seven percent between Physics and Biology.

Biology, Chemistry and Physics have presented similar patterns and uniformity from 2003 onwards. Both Biology and Chemistry have seen an increase in numbers, reaching all-time

peak in 2015, whilst Physics followed the opposite path, reaching its lowest point in 2011 – five point nine percent - and staying relatively low as time progresses.

From 2007 to 2009 no pertinent behaviour to this study's hypothesis was noticeable.

4.3.3 Total

Both male and female candidates contributed to the data presented in Figure 20, which is demonstrated by the almost uniform behaviour of Mathematics, Chemistry and Physics numbers. Due to a rise in the number of female candidates sitting the Biology Leaving Certificate exam from 2003 onwards, an increase in the overall number of Biology candidates can also be concomitantly spotted. In 2015, Biology hit a peak with sixty one point five percent of all candidates choosing to sit the exam.

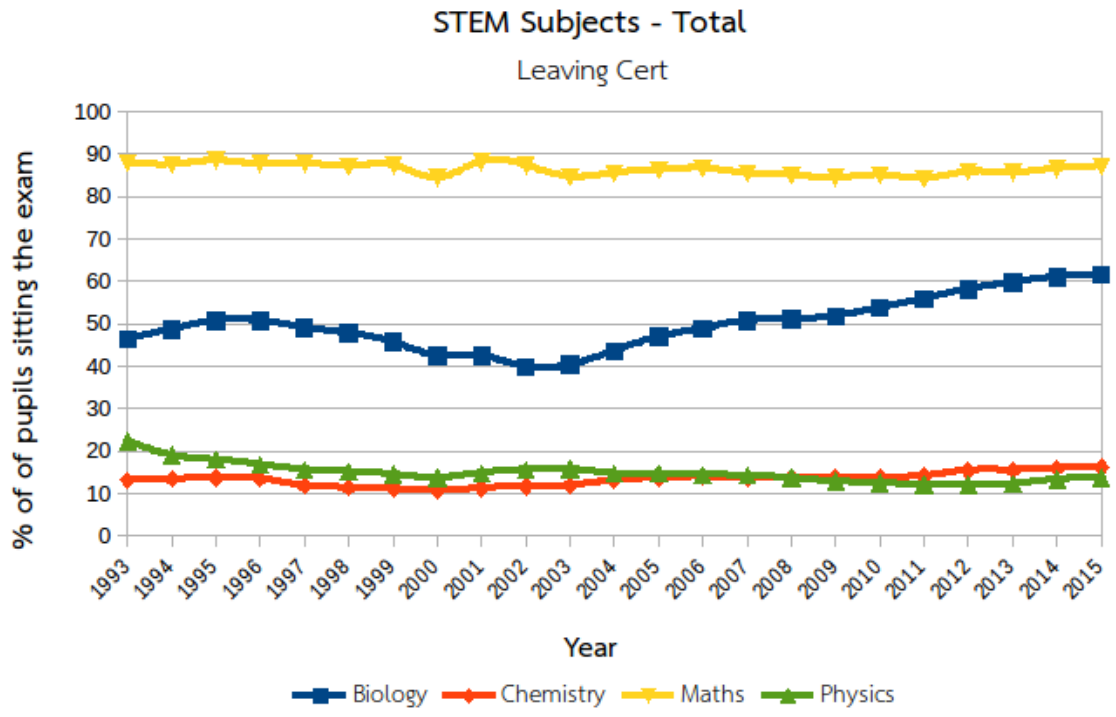


Figure 20 - STEM Subjects: Total

In 1993, almost one quarter of the total number of candidates sat the Physics exam, whilst half the percentage chose to sit Chemistry. Twenty two years afterwards, Chemistry was the choice of sixteen point two percent of the candidates, and Physics lagged behind by almost

three percent. From 1993 until 2008, Chemistry numbers soared and Physics numbers plummeted. The year 2008 marks the inversion point for both subjects, and they continued to diverge since then.

In 2015, the number of Biology candidates accounted for two times the number of candidates sitting Chemistry and Physics combined. Such fascinating facts call for a deeper investigation of their existence, since it may shine a light over the effectiveness of constant efforts from educators to incentivize students - especially females - to pursue scientific careers.

4.4 STEM Leaving Certificate subjects: percentage behaviour throughout the years

Previously in section 4.2 of this chapter, four Leaving Certificate subjects were analysed jointly: Biology, Chemistry, Mathematics and Physics. They are the most relevant to STEM-related college courses admissions and the most likely STEM subjects to be offered at single-sex and mixed schools. But they are not all the STEM-related subjects available to examination at the end of the Senior Cycle. Only the following STEM-related subjects were examined due to them being offered since 1993 (and some even before), following the data collected for section 1: Agricultural Science, Applied Mathematics, Engineering, and Physics and Chemistry. Together with the aforementioned four main STEM subjects in section 4.2, they represent the requirements to specific and general Science, Engineering, Technology, Mathematics and many other associated college courses in the Republic of Ireland.

This section was structured in a way to shed light on the percentage of pupils sitting STEM-related subjects compared to the overall number of pupils sitting the Leaving Certificate exam every year from 1993 to 2015. With it, I hope to test the hypothesis of a potential increase in the number of students choosing STEM-related subjects from 2008 onwards.

4.4.1 Agricultural Science

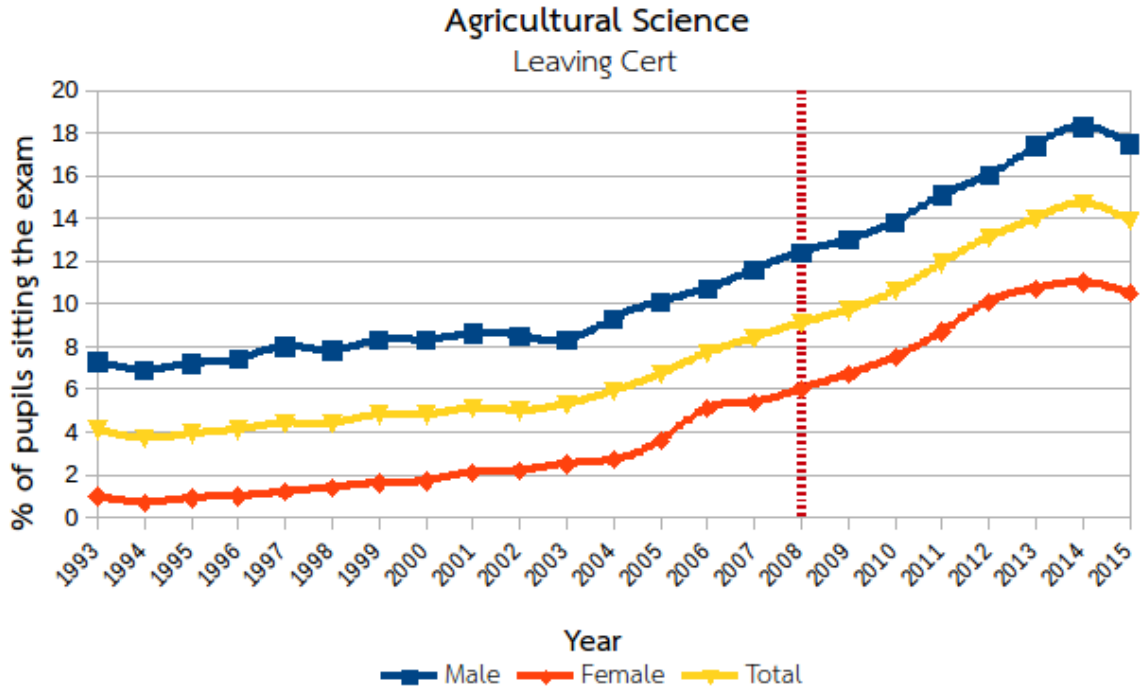


Figure 21 - Agricultural Science

Agricultural Science was first introduced in post-primary schools in 1943, at both Intermediate Certificate and Leaving Certificate, and was initially offered in a restricted number of second-level schools/colleges. Nowadays the subject is offered in 416 of the 685 country's second-level schools. Agricultural Science proves to be popular among students who are planning to study Science, Medicine or Veterinary Science in college.

Although present in 384 of 692 schools in 2015 – more than half of all schools in the country - only seventeen point five percent of boys and ten point five percent of girls sat its Leaving Certificate exam, with a total amount of thirteen point nine percent of pupils (Figure 21).

Every year since 1994, more students are seeking to be evaluated on this subject, with an all-time peak of all genders being achieved in 2014. Agricultural science has been experiencing a steady rise in the number of male pupils since 2003 and a steady rise in the number of female pupils since 1994. Until 2004, pupils had to choose between sitting Biology (Figure 23) or Agricultural Science (Figure 21), and by lifting the bar in the years that followed, we can understand better why both Biology and Agricultural Science numbers have been growing since then.

4.4.2 Applied Mathematics

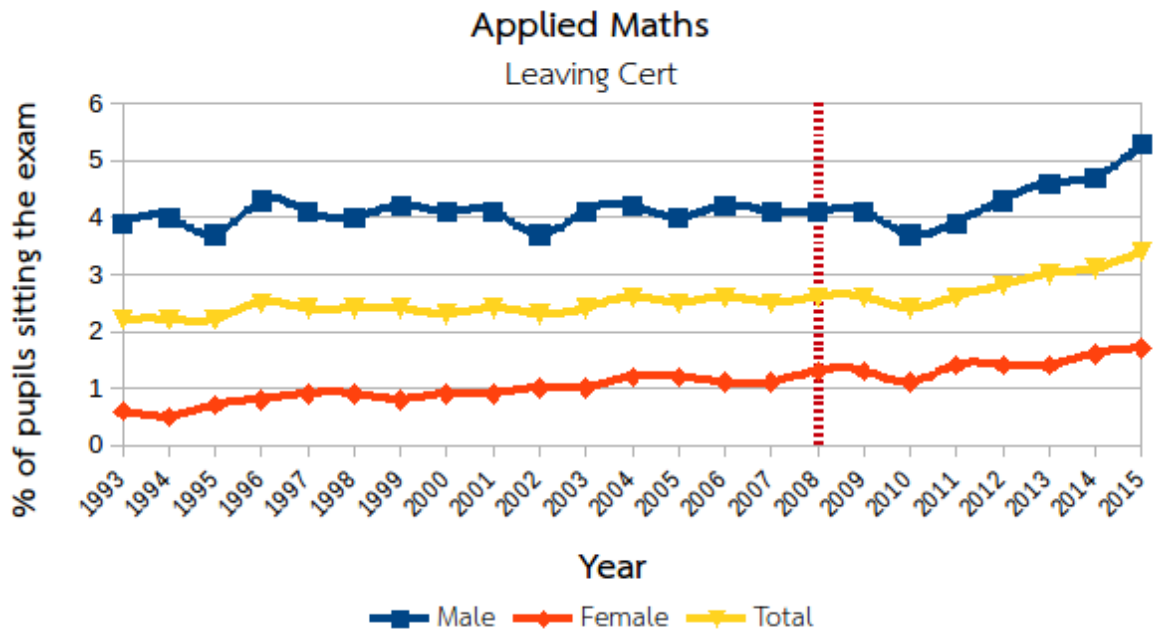


Figure 22 - Applied Mathematics

Applied Mathematics (Figure 22) is a subject commonly associated with engineering and physics, but also finds use in business, environmental studies, economics, finance, and even chemistry and medicine. But due to the fact this subject is not an essential requirement for any courses in the CAO system, the percentage of pupils who choose to sit the exam is quite small (never surpassing six percent).

Since the start of the time-period considered, the percentage of female candidates sitting Applied Mathematics usually remained half the percentage of male candidates sitting the same exam, regardless of the year analysed.

From 2010 onwards, there has been an increase in the number of pupils sitting Applied Mathematics, with an all-time peak being reached in 2015 – five point three percent of males, one point seven percent of females, and three point four percent in total. No big difference was noted at the 2008 mark.

4.4.3 Biology

As previously analysed in section two, Biology (Figure 14) has been on the rise since 2003 for both male and female Leaving Certificate candidates. In 2015, it was picked by seventy three point four percent females, forty nine point one percent males, and sixty one point five percent of the total number of candidates, which makes it the second-most picked STEM subject at the Leaving Certificate exam (losing only to mandatory Mathematics).

The only two college courses in Ireland that explicitly require Biology to be taken into account when submitting Leaving Certificate points are Genetics (in University College Cork) and Human Health and Disease (in Trinity College Dublin); there are another 186 courses which may require the subject, explaining - in part - why a huge amount of students choose to sit the subject at the end of their Senior Cycle studies.

As mentioned before, until 2004 it was forbidden to sit Agricultural Science and Biology together. In recent years, approximately half of all candidates taking Agricultural Science also take Biology, justifying partially why the number of candidates sitting these subjects has been steadily increasing.

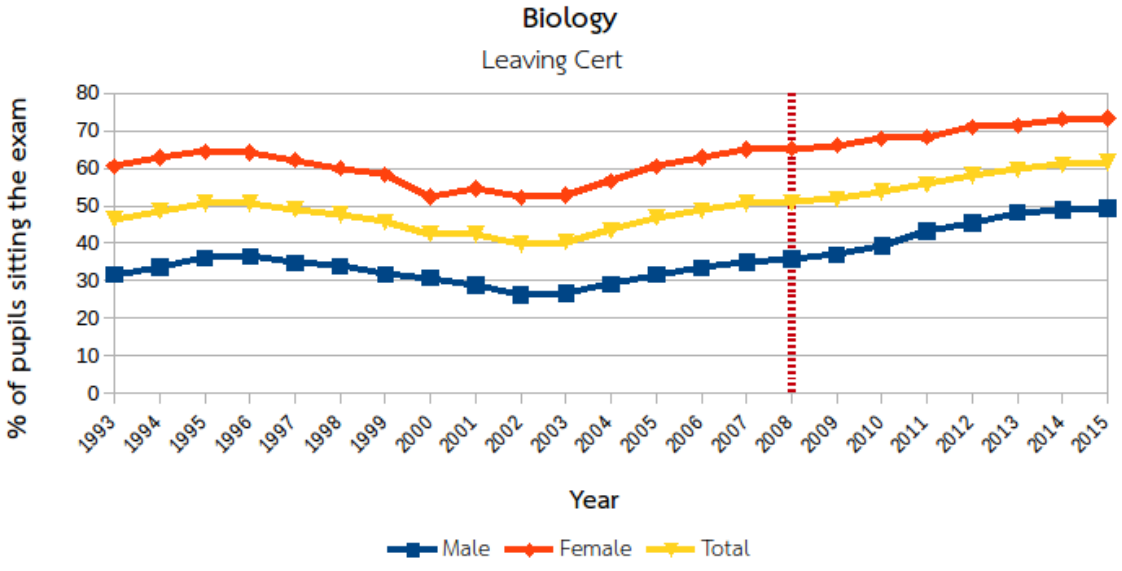


Figure 23 - Biology

4.4.4 Chemistry

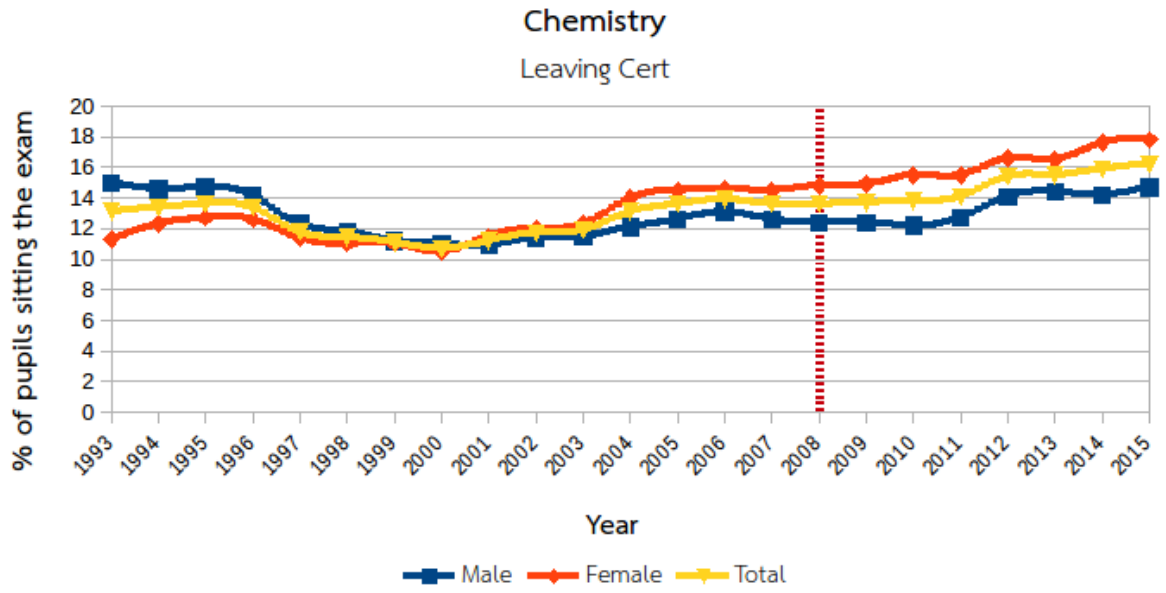


Figure 24 - Chemistry

There are eight college courses which definitely require Chemistry (Figure 24) as a Leaving Certificate subject requirement, including Dentistry and Medicine at University City Cork, and Pharmacy at both Trinity College Dublin, University City Cork and The Royal College of Surgeons in Ireland. The subject is optional in another 189 courses, which are mainly in the areas of Engineering and Health Science. Being an important requirement for almost 200 college courses in Ireland may shred a light on why a considerable amount of pupils decide to sit it every year.

There has been an interesting shift in the number of male and females candidates, starting in 2000. Whilst female numbers have been constantly rising since 1993 – from eleven point three percent in 1993 to seventeen point eight percent twenty two years later - male numbers have fallen from 1993 to 2001, but returned to almost the same percentage it presented in 1993: fifteen percent in 1993 (highest point), to ten point nine percent in 2001 (lowest point), and fourteen point seven percent in 2015. A Revised Leaving Certificate syllabus in Chemistry was introduced in 2000 and first examined in 2002, which may elucidate in part the shift in the percentage of students sitting the Chemistry exam from 2002 onwards.

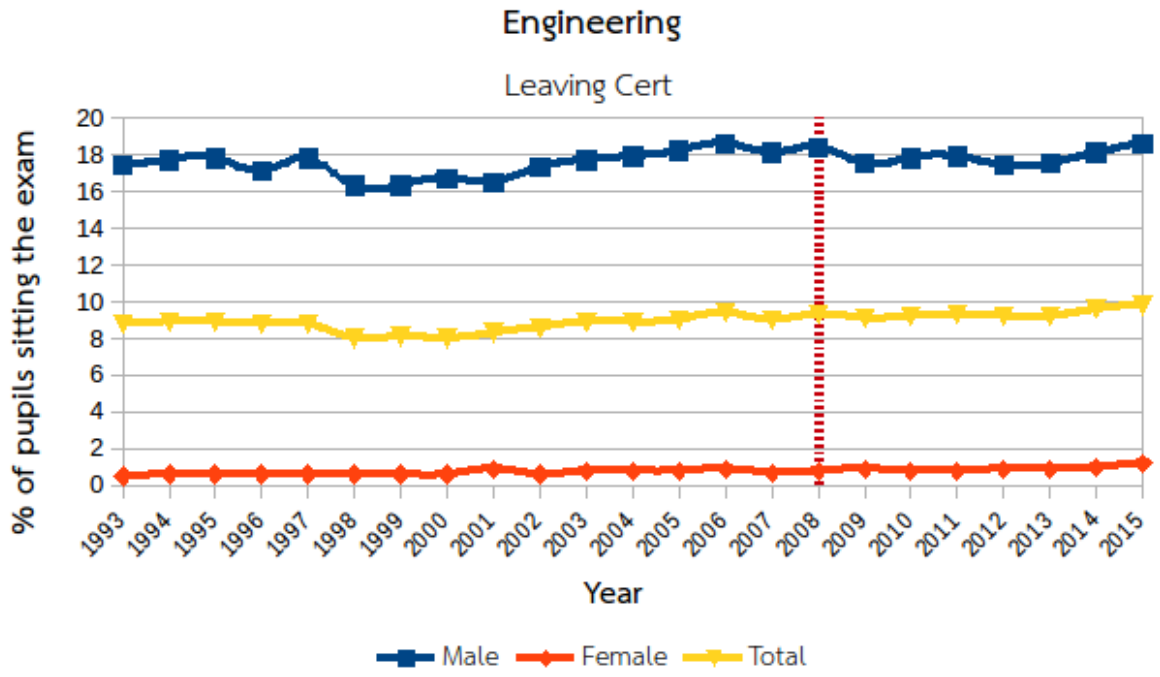


Figure 25 - Engineering

4.4.5 Engineering

The Engineering Leaving Certificate exam presents a similar characteristic to the Applied Mathematics exam: the low percentage of female candidates sitting them every year. In 1993, zero point five percent of all female Leaving Certificate candidates chose to sit Engineering, the lowest point ever registered during the entire time-period considered in this study (Figure 25). In 2015 it was observed the opposite, an all-time peak of one point two percent. Still a small fraction of the eighteen point six percent of male candidates sitting the exam that year, but an increase nonetheless.

No Higher Level Institution in Ireland requires Engineering to be taken in order to apply for any courses, and most All Girls Schools do not offer the subject at the Senior Cycle. Also, no noticeable change was observed in 2008 onwards.

4.4.6 Mathematics

Mathematics is compulsory in every school and a required subject for admission to all CAO courses. Students can choose to sit at one of the three levels: Higher, Ordinary or Foundation. Higher Level Mathematics is a mandatory subject to the admission in fifty one college courses – including Engineering, Theoretical Physics, Computer Science and Mathematics -, whilst 1144 courses definitely require at least Ordinary Level Mathematics. Choosing Foundation Mathematics renders certain CAO courses inaccessible, which have implications for students considering third level education.

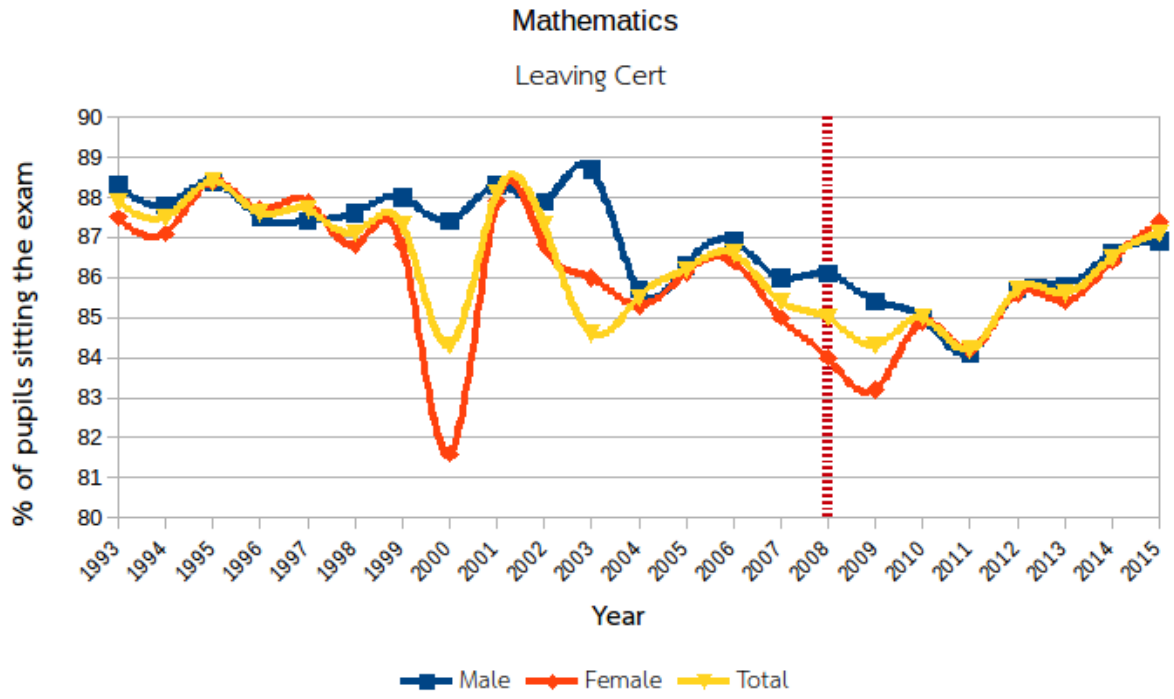


Figure 26 - Mathematics

Because of its fundamental characteristic at both Second Level and Third Level education, Mathematics has a higher percentage of attendance at the Leaving Certificate exam. The total number of pupils sitting the exam reached its lowest point in eighty four point two percent in 2011 (Figure 26), one year before the Bonus Points scheme was introduced.

In 2012, due to a constant decrease in the number of students doing Higher Level Mathematics, a new points system was brought in which awarded twenty five additional CAO points to any pupil who sat the Higher Level Mathematics exam. It is clearly observed the effect it had in the following years: from 2011 to 2015, the number of pupils choosing Higher Level Mathematics rose from eighty four point two percent to eighty seven point one

percent, with almost the same difference being spotted in relation to male and female numbers.

4.4.7 Physics

There are only two Third Level courses that require Physics in their admission process: Theoretical Physics in Trinity College Dublin and University College Dublin. Another 186 courses may require the subject. Despite being offered at the majority of Second Level schools - seventy seven percent in 2015 and seventy nine percent in 2017 - with no substantial difference between Boys Only Schools and Girls Only Schools. It requires a deeper investigation, since the number of pupils choosing to sit the Physics Leaving Certificate exam is way below other subjects (e.g. Biology).

In 2015, only one fifth of male Leaving Certificate candidates chose to sit Physics (Figure 27), against less than seven percent the number of female candidates sitting the same exam. In 2011, the total number of pupils and the female number of pupils hit their lowest points since 1993: for the latter five point nine percent and twelve percent for the former. The lowest number of male pupils was achieved a year after: eighteen percent. Since then, there was a recovery in the numbers, hitting twenty point seven percent of male candidates, six point seven percent of female candidates and thirteen point six percent of total amount of pupils in 2015.

In 1993, the numbers hit the highest points ever recorded on the twenty two years analysed in this study: thirty point one percent of males, nine point one percent of females and twenty two point four percent of total pupils chose to sit Physics; such numbers have never been achieved again.

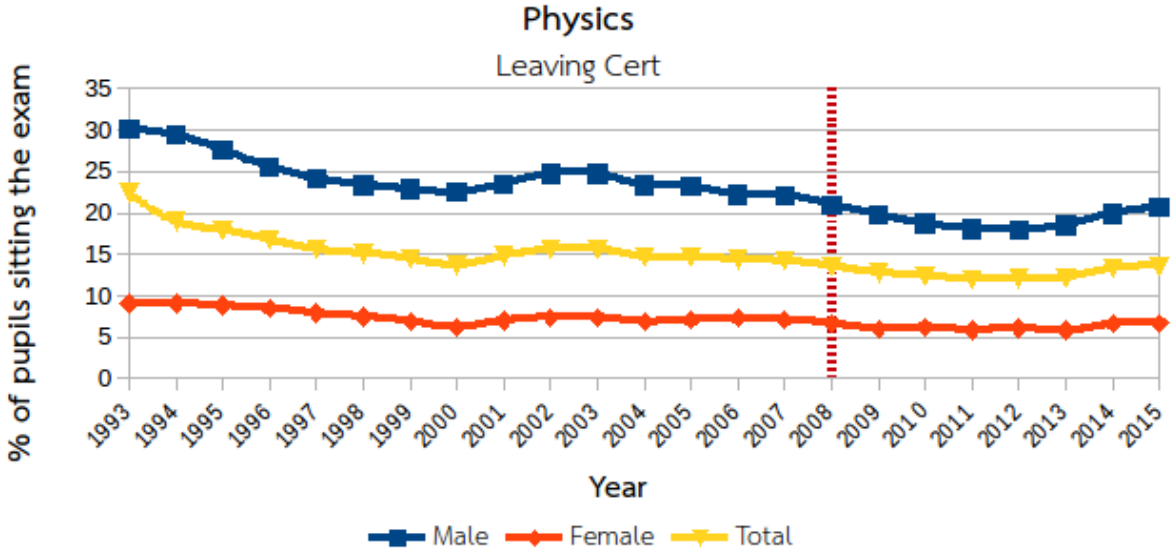


Figure 27 - Physics

There is no direct evidence of any effects the 2008 financial crisis may have had on the Physics Leaving Certificate exam numbers.

4.4.8 Physics and Chemistry

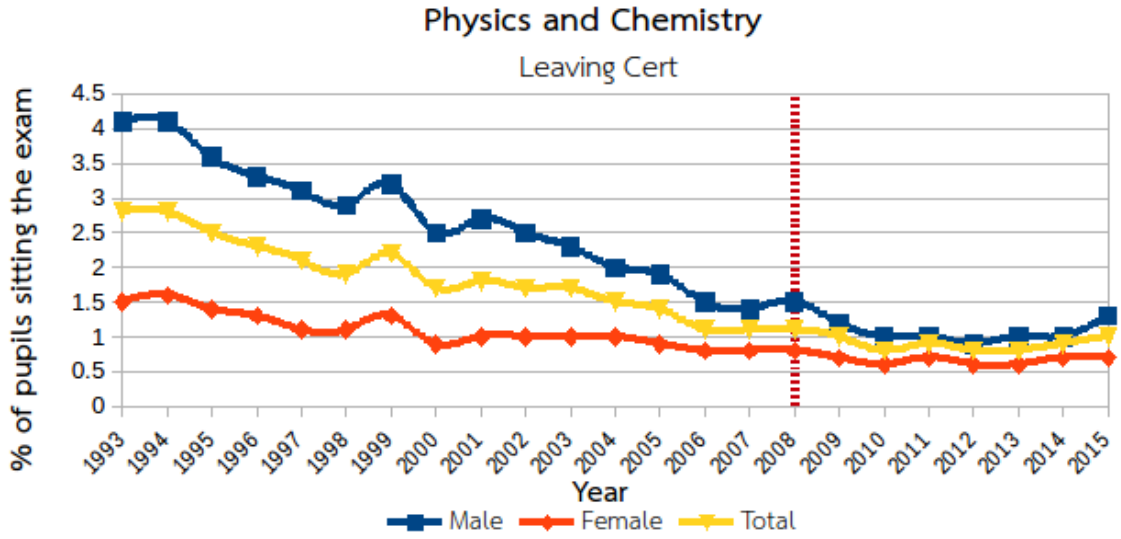


Figure 28 - Physics and Chemistry

Like Engineering and Applied Mathematics, Physics and Chemistry is not an essential requirement for any courses in the CAO system, which reflects on the fact that a small amount of students choose to sit the subject every year (Figure 28).

Despite being named Physics and Chemistry, both subjects are evaluated separately. Aimed and designed to accommodate students who would like a taste of science but may not be comfortable with studying Physics and/or Chemistry as individual subjects, it is offered at very few schools throughout the country. In 1993, 184 of 763 second-level schools offered the course, whilst in 2015 only 52 of 692 did the same. Such low number helps to explain the small amount of students choosing to sit the subject in the time-period considered.

In 1993, four point one percent of male students sat the Physics and Chemistry paper, whilst one point five percent of females and two point eight percent of the total number of pupils did the same. In 2015, the numbers shifted to one point three percent, zero point seven percent and one percent, respectively. The lowest ever recorded points were reached for the first time in 2012: zero point nine percent of males, zero point six percent of females and zero point eight percent of the total number of pupils. Since 2008 the numbers never fully went back to what they were.

4.5 STEM Leaving Certificate subjects: a Higher Level breakdown between genders

This section aims to elucidate the amount of candidates sitting Higher Level STEM subjects at the Leaving Certificate exam and how they behave when plotted against a twenty two years period of time. In order to help clarify possible differences between gender populations, I attributed distinctive colours to each variable – red to female and light purple to male. In connection to this study's hypotheses, one ultra-fined dash red line divides the graph in two segments: before and after the 2008 financial crisis.

4.5.1 Agricultural Science

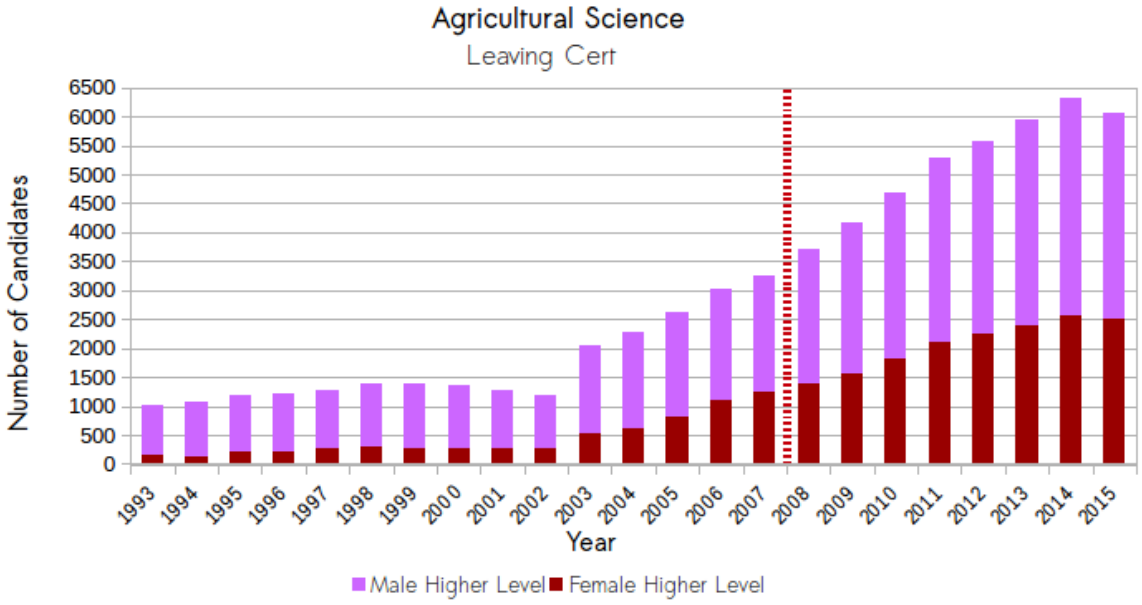


Figure 29 - Agricultural Science

From 2003 onwards, a clear pattern is noticeable: the number of both males and females choosing to sit Higher Level Agricultural Science has increased year by year (Figure 29). Starting with approximately 900 male and 150 female candidates in 1993 to more than 3500 male and 2500 female candidates in 2015, an increase of almost three hundred percent in the number of male candidates and an astonishing increase of more than one thousand and five hundred percent in the number of female candidates in twenty two years. The biggest number of candidates sitting the exam during the time-period considered happened in 2014 with a total of 6329 of pupils.

4.5.2 Applied Mathematics

As mentioned before in this study, Applied Mathematics is not the most female-friendly Leaving Certificate subject, and I shall elucidate why in the Discussion section. What we can see so far is that while the number of male candidates sitting Applied Mathematics Higher Level has been oscillating quite randomly throughout the time-period considered (Figure 30), the number of female candidates has remained low despite the fact it has increased if we compare the numbers from 1993 to 2015. In 1993, approximately 150 girls sat the exam, one third of the amount of girls sitting the same subject in 2015. Whilst the number of girls had

tripled in twenty two years, if we analyse what happened to the number of boys, we will see that it went 883 in 1993 to 1297 in 2015, badly doubling the amount.

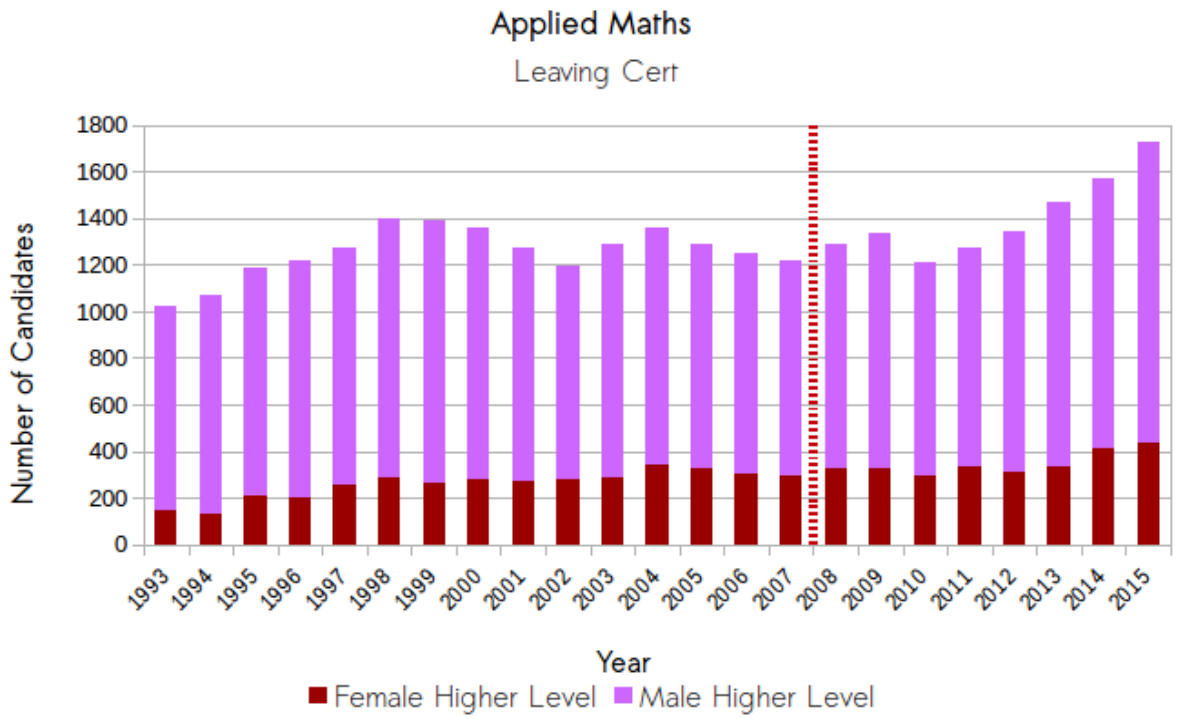


Figure 30 - Applied Mathematics

So far, the most successful year to Applied Mathematics when it comes to pupils sitting the exam has been registered in 2015, with a total of 1729 candidates.

4.5.3 Biology

Reiterating what we have seen before in this section, when it comes to Biology as a Leaving Certificate subject, the number of females sitting it is way higher than the number of boys doing the same, regardless of the year analysed. The same pattern continues when plotting the number of candidates sitting Biology Higher Level (Figure 22). Whilst the number of female candidates showed little variation during twenty two years, the number of males has been increasing each year, reaching a maximum point of 9685 male candidates in 2015. The same year also registered the highest amount of female candidates with 15910, almost twice the amount of males. Biology Higher Level is the most popular STEM subject at the Leaving Certificate exam, even beating Mathematics (Figure 17) every year since 1993 (including the years which the Bonus Mathematics system was included).

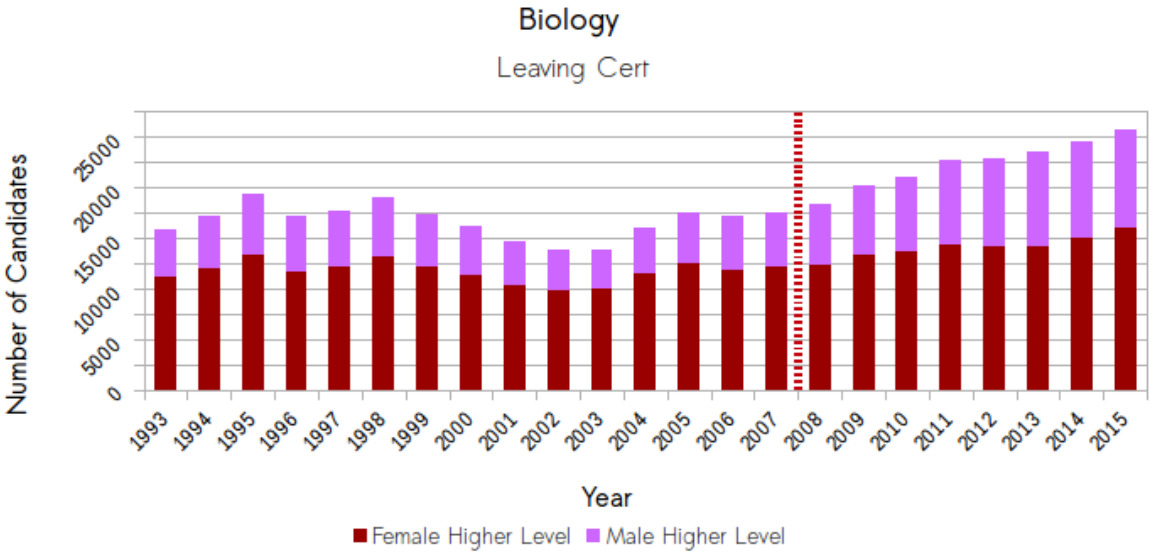


Figure 31 - Biology

4.5.4 Chemistry

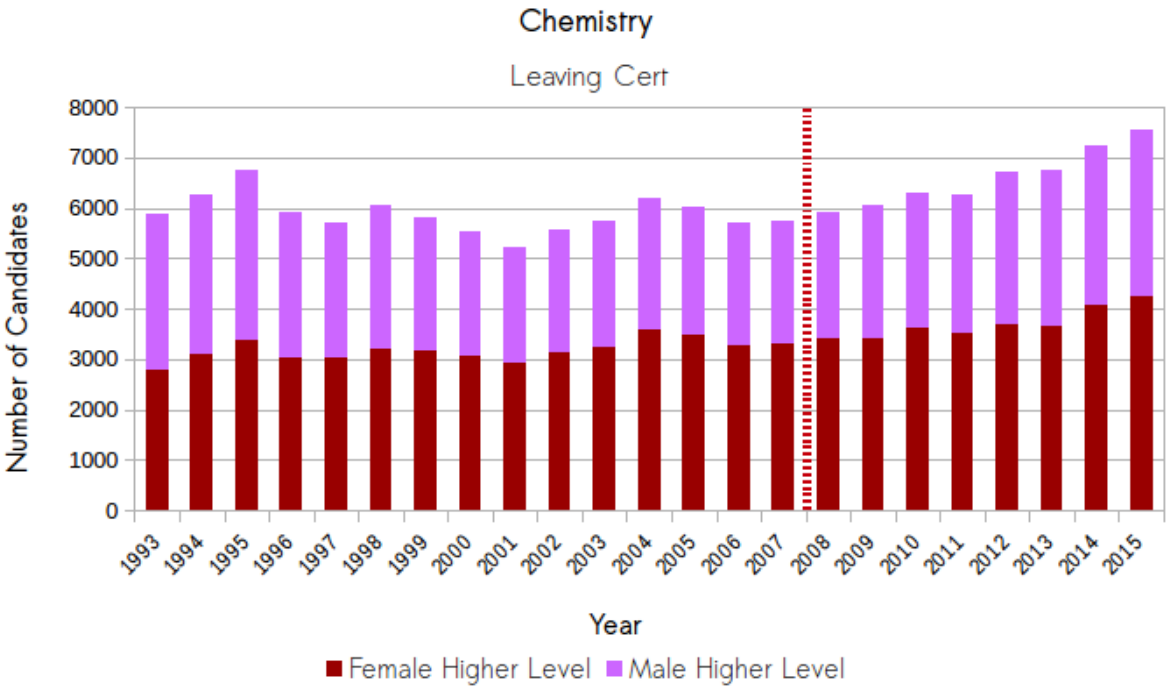


Figure 32 - Chemistry

In 2015, more than 25000 candidates sat Biology Higher Level (Figure 31), an all-time high for the subject. The same occurred to Chemistry candidates (Figure 32), but they made only one third of the number of Biology candidates. It is safe to say more and more students are

choosing to sit some Higher Level STEM subjects – like Biology and Chemistry – and this fact might have a substantial correlation towards their choice of future careers. Since 2008 the number of both males and females choosing to sit Chemistry has been steadily increasing, rising from 3400 female candidates and 2504 male candidates in 2008 to 4257 female and 3276 male candidates in 2015 – the highest amount of pupils in twenty two years.

4.5.5 Engineering

Seeing as Engineering is not a required subject to any admission to Higher Education courses in the Republic of Ireland, choosing to take its Higher Level Leaving Certificate exam must be a combination of opportunity – the school offers the subject – and ability – the student feels comfortable with Mathematics and Physics. Despite not being quite so popular among female students, it is difficult to pinpoint the exact reasons why the ratio of boys to girls is incredibly high, reaching an astounding ratio of one female to forty five male candidates in 1993 (Figure 33).

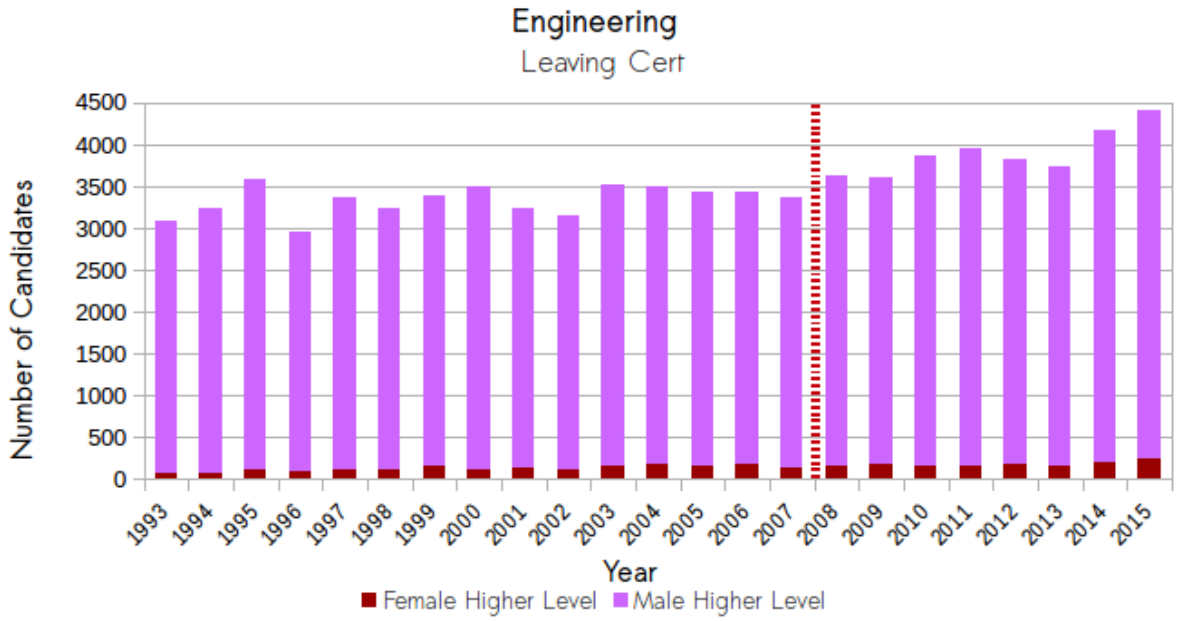


Figure 33 - Engineering

Insofar as the analysis go, the number of male candidates has been rising, on average, since 2008. The number of female candidates presents a non-uniform behaviour throughout the years, with its highest point at the 2015 mark, and the lowest registered in 1993. So if

considering the beginning and the end of the time-period, there has been an increase in the number of female candidates, despite its variation from year to year.

4.5.6 Mathematics

The numbers of Mathematics Higher Level candidates (Figure 34) has been oscillating from 1993 to 2015. There is a clear increase in the number of both male and female candidates in 2012, which can be attributed in part to the implementation of the Bonus Maths system. In 1993, the number of male candidates was 3942 whilst the number of female candidates was almost half of it. In 2015, the same variables presented values of 7695 of males and 6996 of females. It took females twenty two years to almost hit the same number of male candidates, and one can argue that the implementation of the Bonus Mathematics system had an evident and positive influence to it.

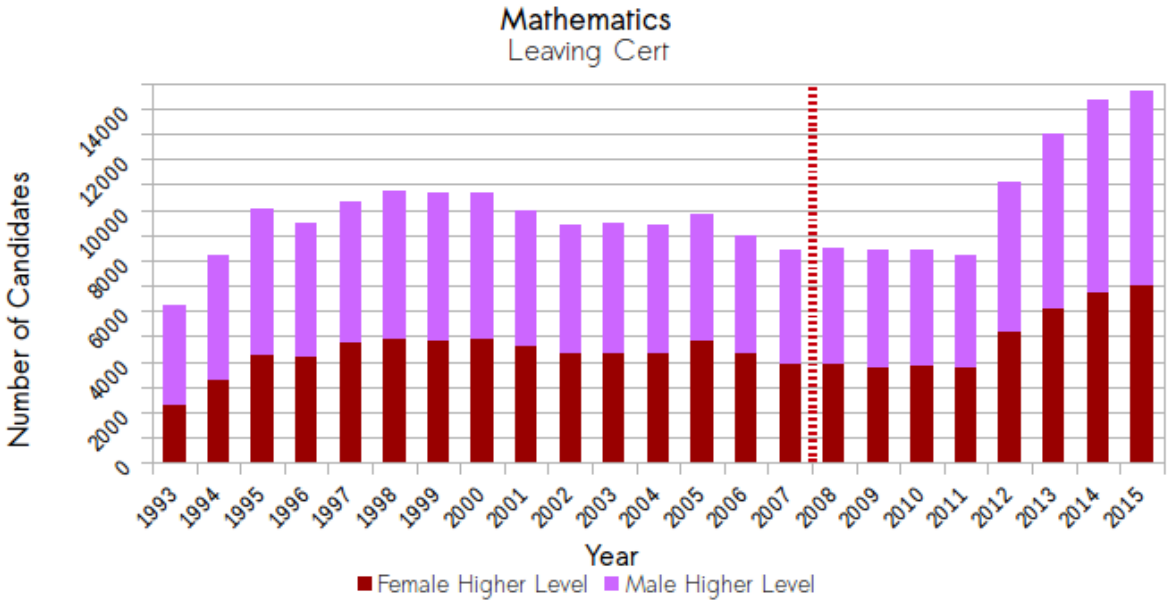


Figure 34 - Mathematics

4.5.7 Physics

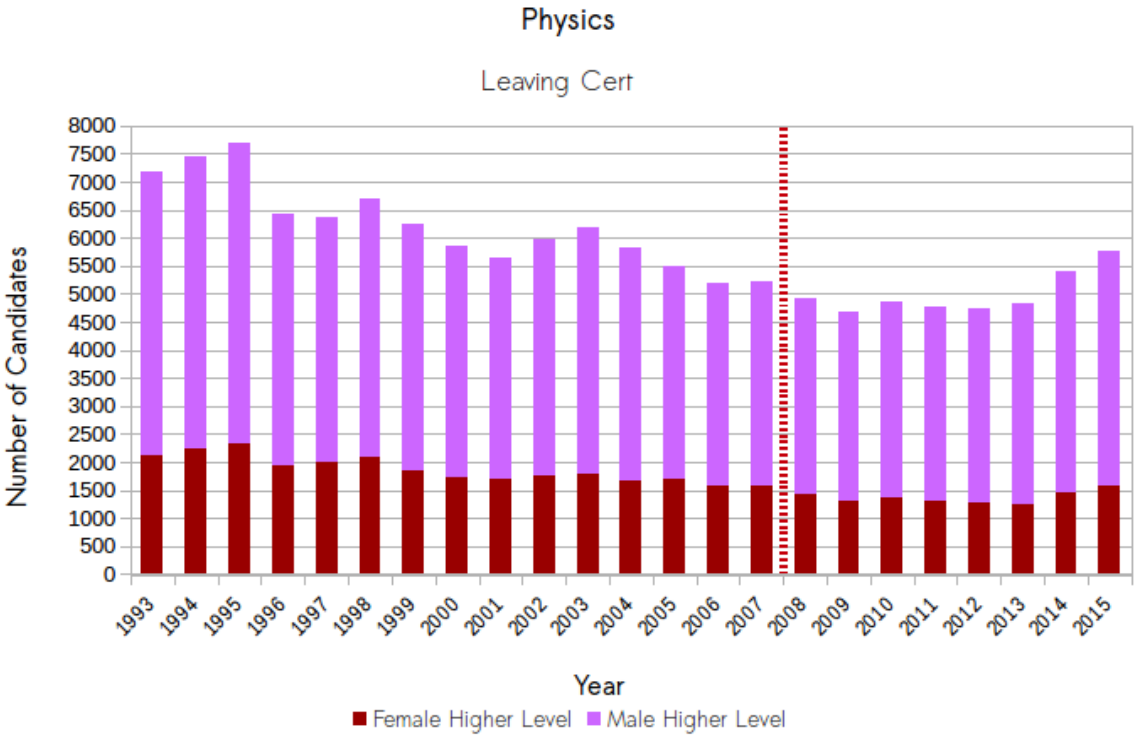


Figure 35 - Physics

The number of candidates sitting Physics Higher Level has never been greater than it was in 1995 for both males and females (Figure 35). It reached an all-time low in 2009 but it has been gaining traction since then. Females still represent one third of the total amount of candidates – 1568 females and 4196 males in 2015, and the fact the subject is offered in most schools but it is not required to many admissions to college courses (in fact it is just required in admission to Theoretical Physics) might help us to understand why Physics Higher Level is not picked by a great amount of students.

4.5.8 Physics and Chemistry

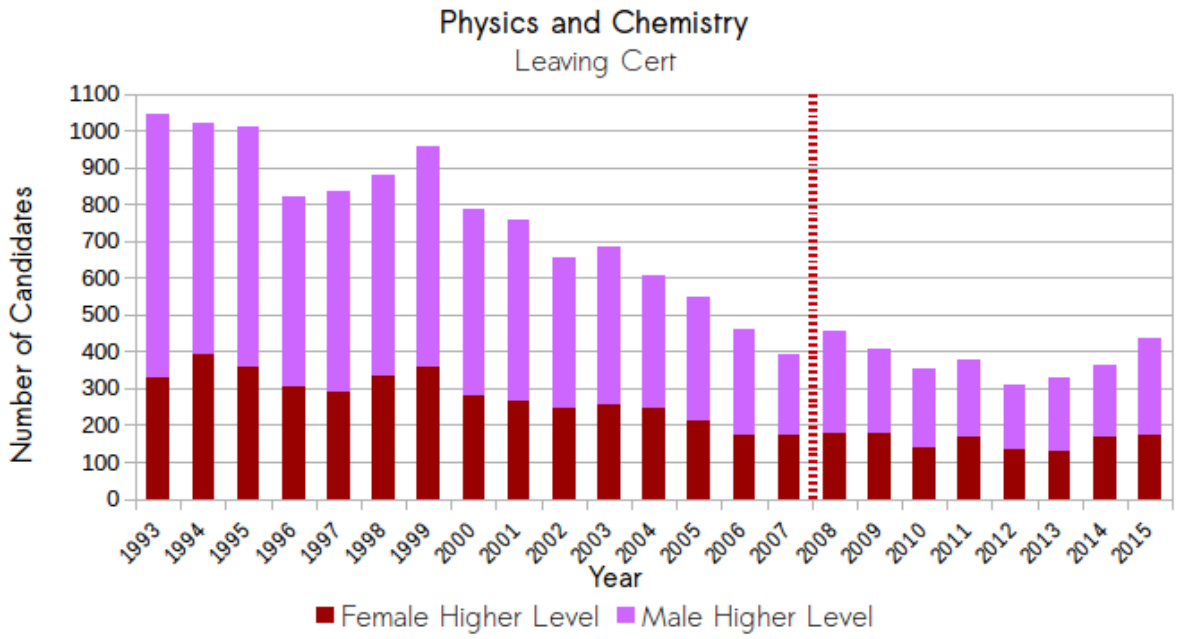


Figure 36 - Physics and Chemistry

Each year, fewer students decide to sit Physics and Chemistry Higher Level (Figure 36) at their Leaving Certificate exam. Starting at the highest numbers for female and male candidates in 1993 – 330 for the former and 717 for the latter - and falling to the lowest numbers in 2012 – 132 female candidates and 177 male candidates – the numbers have increased in the last three years analysed.

It is interesting to notice how the number of male candidates has been decreasing faster than the number of female candidates, and further investigations could shed some light on this fact.

5 Discussion of Research Findings

5.1 Introduction

When I first started thinking about what questions I wanted to answer with this dissertation, back in 2017, it appeared to me that the whole process would be pretty straight-forward: ask questions, form hypothesis, track down research methods, gather data, elaborate, discuss it, done. Looking from the outside, one can attest that it was exactly what happened, and in that

particular order, no bumps on the road. The truth is, we are never really ready for all the challenges postgraduate study will present us. From having almost no existing literature to base yourself on, to the fact that governmental agencies sometimes don't keep a consistent record of how many schools were once operating in the country, and many more unexpected deviations. Although incredibly frustrating at times, this two-year journey was very rewarding.

The objective of this study was to analyse if the 2008 financial crisis affected the pursuit of STEM subjects at the Leaving Certificate exam by pupils, in Ireland, as they reached the end of their Senior Cycle. In theory, difficult times can alter adolescents' career aspirations since they answer to external stimuli from family, peers, friends, teachers, etc. (Altonji, 1993; Riegle-Crumb, Moore and Ramos-Wada, 2011; Arcidiacono, Hortz and Kang, 2012), and in order to pursue a career, the most common path is to go through college first. In Ireland, it means to sit the Leaving Certificate exam (which includes science, technology, engineering and Mathematics - STEM - subjects), get a certain amount of points and then apply to one's course of choice.

For high-earning majors, graduating into a recession increases their earnings advantage, and for low-earning ones, it increases their disadvantage (Altonji, Kahn and Speer, 2013). This is true also for Ireland, as Savage et al. (2015) showed. By analysing snapshots of the income distribution in Ireland from 2008 to 2013, they demonstrated that the greatest falls in income were for the bottom decile (poorest ten percent) of the population (Savage et al., 2015). I hypothesised that, since the recession had a major impact on the families' earnings throughout the country, some spillovers would affect students' perceptions of both the economy and their future as citizens and workers.

In uncertain times it is advisable to play safe, and what is safer than choosing a job that pays well? If everything else is falling apart, one would try to minimize the risks of losing their job by choosing a career that is stable and/or at least will enable someone to save some earnings. In economic terms, one would try to minimize risks whilst maximizing utility. These jobs are, today, mainly concentrated in the areas of Health, Business and STEM (Carnevale, Smith and Strohl, 2013), which are areas that, overall, require specialized third-level education degrees. For example, a study performed by Kinsler and Pavan found that on average, college

graduates majoring in Science or Business earn significantly higher wages than other college graduates, often on the order of twenty five percent or more (Kinsler and Pavan, 2014).

5.2 Limitations

In Ireland, each Higher-Level institution has its own admission criteria, and within each institution there are different majors (or courses) that require specific Leaving Certificate subjects and grades from candidates. My objective was to plot the variation in the number of second-level students choosing from a list of subjects, for their Leaving Certificate, throughout the years in order to see if there were major shifts or unexpected behaviours.

I started first with STEM-related subjects: Agricultural Science, Applied Mathematics, Biology, Chemistry, Engineering, Mathematics, Physics, and Physics and Chemistry. I also plotted graphs for other subjects (e.g. Home Economics, French), they can be found at the Appendix Section. I chose to collect data from 1993 (a year which saw the introduction of a different points system) and progress forward until 2015, when the last Annual Report was made available to public online consultation.

For each graph related to a subject, I collected the number of males and females sitting that subject at Ordinary and Higher Levels, and added both amounts together, which resulted in six variables plotted against a period of time of twenty two years. This approach allowed me to see the progression of the genders before and after the recession within each STEM subject.

The fact that the objective of this study was not to engage in rigorous statistical methods, at least at first, linear progression was not applied. Nonetheless, because each University asks for certain subjects and grades, one possibility is that I would have to engage in a longitudinal study with a statistically substantial number of students throughout their Senior Cycle (or earlier), undergraduate course, beginning of their careers and maybe further on. Even so, that hypothetical study would still have its limitations. For an interesting study on the statistics regarding third-level STEM students from the University of Limerick, see O'Donoghue, Faulkner and Hannigan (2010); for a study on the individual and school factors associated with taking science subjects within upper secondary education in the Republic of Ireland, see

Smyth and Hannan (2006); for the first mixed-methods longitudinal research study focused on the experiences of secondary students as they moved through the school system in Ireland, see Smyth (2014).

My supervisor, Dr. Joseph Roche, and I envisioned assembling a focus-group composed of STEM undergraduates from the University of Dublin in order to query them about the reasons why they chose their courses. Although it would add a deeper understanding of people's motives to choose STEM courses to this study, self-reported data present a few constraints. We would not be able to find substantial, or direct, correlation from current undergraduates and the recession which happened ten years ago, therefore we decided to drop the idea. I would say there is value in the aforementioned endeavour for those who have the resources and the time to pursue it.

I was aware of the limitations of the approach I took: choosing to sit a STEM subject at the Leaving Certificate may or may not lead to a major, and/or career, in STEM, although it can help to shed light over the ability of Irish students in Mathematics and other scientific subjects. The role ability plays in a person's future choice of career is well documented in the literature (see Blackburn and Neumark, 1993; Galor and Moav, 2000; Krueger and Lindahl, 2001; Maltese and Tai, 2011), and while some students may not engage in a STEM major in a time to come, the fact they chose STEM subjects means they thought their chances of earning more points were higher by doing so. It does not imply they had better grades in those subjects whilst in secondary-level schools, but it does correlate with their perceived ability for those subjects (Maltese and Tai, 2011).

5.3 Results

There are results I would like to highlight. Despite not finding anything really substantial to help to make a strong case for my hypothesis, I did find some interesting trends.

Overall, female candidates are less likely to choose Higher Level STEM subjects than their male counterparts. Except for Biology and Chemistry, female Higher Level numbers were, to a certain degree, lower than male Higher Level numbers. A review-paper written by Ziegler, Montoya and Jiang (2007) showed that "women obtain more than half of U.S. undergraduate

degrees in Biology, Chemistry, and Mathematics, yet they earn less than twenty percent of Computer Science, Engineering, and Physics undergraduate degrees", and that "gender differences in interest in Computer Science, Engineering, and Physics appear even before college" (Ziegler, Montoya and Jiang, 2007). If the Higher Level Leaving Certificate exam is anything to go by, we can say the same happens in Ireland, at least at Second-Level education. Chemistry, Biology, and Mathematics are sought more by females than Physics, Engineering, and Applied Mathematics, yet we cannot blame it all on choice, we have to look at how the opportunities are presented to students.

Unlike the U.S., which applied the value of gender-neutrality in primary and secondary public schools since the beginning of the twentieth-century and had, in fact, by 1900, "considerably more girls than boys in attendance in the upper secondary school grades" (Goldin and Katz, 2008, p. 133), Ireland still perpetuates the division between sexes by allowing the existence of single-sex schools. Apart from all the social outcomes that may result from gender-segregation, academic outcomes are being compromised as well. I shall extend this thought and elaborate it deeply in the next section of this chapter by presenting research on the subjects available to different schools.

5.3.1 Mathematics

For Mathematics, the difference between the number of females and males sitting both at the Higher and Ordinary levels was practically non-existent from 2008 onwards. What pops up is the increase in Higher Level numbers for both sexes starting in 2012, and we can associate this to the introduction of the Bonus Points scheme (Treacy, Faulkner and Prendergast, 2016), which was created to incentivize students to opt to study the subject at Higher Level (Treacy, 2018). While the number of Higher Level candidates rose, the number of Ordinary Level candidates dropped. I decided to leave Foundation Level numbers out of the Results chapter due to it not being usually used to universities' admissions, but it can be found in the Appendix. A thoughtful questioning on the learning effectiveness of the Bonus Points scheme can be seen in Treacy (2008).

It is also worth noticing Mathematics is the only STEM subject where the number of Ordinary Level candidates is still greater than the number of Higher Level candidates for both

sexes. This may be due to most Universities accepting Ordinary Level grades for non-STEM courses' admissions, but still requiring at least a "pass" for all admissions. Since 2012, with the introduction of the Bonus Point scheme, the gap between the number of Ordinary and Higher level candidates has been steadily decreasing. It will be interesting to see how this gap behaves in the years to come.

The Project Mathematics curriculum was introduced into post-primary schools on a phased basis from 2008 onwards and in other schools from 2010. It was designed with the objective to provide a syllabus which was more centred on practical problem-solving skills. Some drastic changes in the amount of Leaving Certificate points from 2012 onwards might be attributed to this new curricula. For a critique of the new syllabus, see Kirkland (2012), and for a rebuttal of it, see National Council for Curriculum and Assessment (2012).

5.3.2 Agricultural Science

The power, scope and importance of the agri-food industry in Ireland is undeniable. A family tradition which had to rapidly evolve to an international business in order to comply with Europe's regulations and market-demands, the agri-food contribution to Ireland's economy is vital. In 2017, employment in the agri-food sector accounted for 174,400 jobs, a seven point nine percent of total employment according to the CSO Labour Force Survey, and it represented seven point eight percent of Ireland's GNI[7].

Most farms are still held and maintained by families, where the owner eventually passes the businesses to her/his child, and within an environment where technology never stops advancing, it is extremely important that the child be educated. This trend reflects positively on the number of candidates sitting the Agricultural Science paper from year to year. Although not being a requirement to any third-level course admission, it is a subject which provides knowledge that can be used regardless of the student deciding or not to engage in further education.

There is a noticeable increase in the numbers of males and females sitting Higher Level Agricultural Science and Biology, two highly sought subjects, from 2003 onwards. Before

[7] Central Statistics Office Labour Force Survey (2018, January 16). Retrieved from https://www.cso.ie/en/releasesandpublications/er/lfs/labourforcesurveyquarter32017/

2004, both subjects could not be sat together, which forced students to choose between the two. Agricultural Science is a subject which has a lot in common with both Biology and Chemistry, so it is likely that a student who has good grades in one will have good grades in the others. More and more students are sitting Agricultural Science each year, and this is a trend worthy of future analysis (especially due to Britain's exit from the European Union).

5.3.3 Applied Mathematics

Applied Mathematics has a curriculum mainly composed of Mathematics applied to Physics, an arrangement which provides tools that are valuable to those who choose to major in Physics or Engineering. Despite its usefulness, no third-level institution makes it a requirement to their admission processes, so it is likely that students who sit Applied Mathematics are students who have great ability in the subject; therefore, it is plausible to infer they choose to enter courses whose curricula are heavily composed of Mathematics and Physics (e.g. Theoretical Physics and Mathematics).

Despite not being very popular, there has been an increase in the numbers of Higher Level candidates since 2010, which can be attributed to the increase in the numbers of schools providing the subject at the Senior Cycle (as shown further in this chapter).

5.3.4 Biology

Biology is the most popular of all non-mandatory subjects, and the number of candidates sitting the subject has been on all-time high since 2003. As mentioned before, this phenomena is likely due to the lift on the Agricultural Science/Biology ban. Also, almost three times more girls sit the subject than boys at both Higher and Ordinary levels. If assuming that a great number of girls who sit Biology are going to choose Healthcare majors later on, it would be interesting to analyse their reasons for doing so. It may relate to the certainty of entering the job-market straight after finishing college, and the stability healthcare jobs present in a recession, like it was demonstrated that some healthcare careers (such as Medicine and Nursing) are "recession-proof" (Dolfman, Insco and Holden, 2017; Chen, Sasso and Richards, 2018; Dolfman, Insco and Holden, 2018). There is room for

inquiries on the economic returns of graduating in healthcare majors in Ireland before and after the recession.

Such a tendency is not only observed in Ireland, and was previously studied by Miller, Slawinski Blessing and Schwartz (2006) in the U.S., which found that "females often planned a science major mainly because they needed a science background in order to enter a health profession such as medicine or physical therapy"; by Prokop, Prokop and Tunnicliffe (2007) in Slovakia, Baram-Tsabari and Yarden (2008) in Israel, and Goldin and Katz (2008) in the U.S., just to mention a few. Further research is advised.

Also, Biology is an essential subject for Pharmacy majors, and Ireland is home to nine out of the ten largest pharmaceutical companies in the world. The country is a world leader in the area of pharmaceutical manufacturing, being the seventh largest exporter of medicines. The pharmaceutical industry "comprises 160 foreign and national companies and employs 25,000 people directly and a further 25,000 indirectly" according to the data of U.S. Department of Commerce's International Trade Administration[8]. This may indicate that students are aware of how financially rewarding it is to major in Pharmaceutical-related courses.

5.3.5 Chemistry

In total, there are eight courses that mandatorily require grades on Chemistry (including Dentistry, Medicine and Pharmacy in University College Cork, and Pharmacy in Trinity College Dublin), and another 182 that may require grades on the subject. As with Biology, Chemistry is a vital subject for both Veterinary, Science, Agricultural Science, Pharmacy and many more Healthcare courses, and if chosen to be sat alongside Mathematics, it can indicate a candidate's tendency towards Chemical and/or Material Engineering.

Childs and Sheehan (2009) noticed that students who are weak in Mathematics perceive more topics difficult in Chemistry compared to those are strong at Mathematics (Childs and Sheehan, 2009). It would be interesting to analyse the proportion between the number of students who sit Chemistry alongside Mathematics for both Higher and Ordinary levels in order to complement the authors' semi-longitudinal study.

[8] Ireland Drugs and Pharmaceuticals - Commercial Guide (2017, January 13). Retrieved from https://www.export.gov/article?id=Ireland-Drugs-and-Pharmaceuticals

5.3.6 Engineering

Engineering is not a subject mandatory to any CAO courses, but thanks partially to Ireland's fourteen Institutes of Technology - represented by the Technological Higher Education Association - which offer fifty one percent of their courses in STEM areas[9], there are more and more pupils choosing to enrol in Engineering during their Senior Cycle.

In the past years, we have seen many initiatives supported by the government (e.g. WITS, Smart Futures, and STEPS) and by private companies (such as Google and Microsoft), with the objective of raising awareness about Engineering and other Science-related careers. In research conducted by Kennedy and O'Dwyer Duggan in name of Science Foundation Ireland, it was observed that "the availability of STEM subjects at Leaving Certificate level was an important factor as students who had these options open to them (and selected them) were much more likely to go on to study STEM in college"[10]. The authors also found that "the biggest stand out factors influencing undergraduates' choice of college course were that they felt they would fit in (sixty two percent put this in their top three), and career prospects of the course (fifty six percent)", and "twenty three percent said the entry requirements played a role in their decision."

With this in mind, it is straightforward to assume a chunk of students plan ahead of their Leaving Certificate exam, choosing to sit subjects that they have a greater ability in, either naturally and/or reinforced by effort and good grades - two factors which cannot be dissociated from each other (Schick and Steckel, 2015).

Another interesting finding by Kennedy and O'Dwyer Duggan (2014) is that "parents of STEM undergraduates and of males are more likely to advise them based on the fact that there would be jobs after completing the course (fifty two percent and forty eight percent respectively)", which indicates a common concern among Irish families. Research in this area would be recommended and appreciated, especially centred on a possible gender-bias

[9] Facts and Stats - Technological Higher Education Association. Retrieved from http://www.thea.ie/facts-and-stats/

[10] Science Foundation Ireland STEM Research (2014, December). Retrieved from https://www.smartfutures.ie/sites/default/files/resources/basic/SFI%20Smart%20Futures%20STEM%20research%20Final%20Report%202014.pdf

discrimination since only one point two percent of all women enrolled at the Leaving Certificate exam in 2015 decided to sit Engineering.

5.3.7 Physics

As pointed out in the previous chapter, there is a resonant disparity between the genders: fewer females than males chose to sit the exam at both Ordinary and Higher Levels, and both numbers have decreased in the past twenty-two years. More than twice the number of numbers sit Physics Higher Level if compared to the amount of females doing the same, and there is no indication of a shift in the future.

Physics requires both mathematical and interpretative abilities, which makes it a more difficult subject for students to master. Abstraction lies at the core of the subject, and many phenomena studied at Physics classes are somewhat presented as hypothetical due to the lack proper laboratories and equipment. Not that both are necessary for the subject's understanding, and if not structured properly it can even harm students' learning process - as demonstrated by Wilcox and Lewandowski (2017) and Quinn et al. (2018).

Only Theoretical Physics in the University of Dublin requires grades in Higher Level Physics, and another 189 courses may require grades in the subject (mainly Engineering and Health courses). This can clarify why such a small amount of students decide to pursue Physics in their Senior Cycle. More information regarding possible career prospects are likely to improve a student's perception of how valuable the subject is for most university courses and also life in general.

Unfortunately, due to the 2008 financial crisis, the Irish government, following the European path, decided to restrict funds destined to certain areas of basic research. Such attitude asphyxiated many areas of fundamental science (e.g. Astrophysics, Particle Physics and areas of the life sciences), whilst helped to develop others[11] (e.g. Basic Biomedical Science, Nanotechnology, Advanced Materials, Microelectronics, Photonics and Software Engineering). As pointed out by Roche, O'Neill and Prendergast (2016)

[11] Report of the Research Prioritisation Steering Group (2011). Retrieved from https://dbei.gov.ie/en/Publications/Publication-files/Research-Prioritisation.pdf

[T]his has placed even more responsibility on higher education to help prepare young people for a competitive STEM environment as basic research in Ireland is not supported and does not offer structured career paths for early-career researchers. (Roche, O'Neill and Prendergast, 2016).

Both teachers and students might have sensed this reallocation of funds as an opportunity to revaluate their decisions concerning future career prospects.

There is a constant effort from Physicists, teachers and governmental bodies to improve instruction and formation of current and new Physics professionals. For example, the Institute of Physics - a leading scientific society - places special emphasis on supporting physics teachers by promoting in our schools the value, joy and benefits of a knowledge of physics and its applications. Established in the 1970s in both Northern Ireland and the Republic of Ireland, it helps to promote science and science-based learning and to influence science policy in both the Houses of the Oireachtas and the Northern Ireland Assembly.

But not only Physics professionals receive an extra incentive to improve their practices. For example, the University of Dublin is home to the Walton Club, a not-for-profit STEM Education programme created in 2014 and aimed at delivering an innovative and interactive educational experience to secondary school students. It is expected that this initiative will help to expand the formation of others around the country, consequently reaching more students and assisting to change the STEM scenario for secondary students in Ireland.

5.3.8 Physics and Chemistry

This course combines parts of both Leaving Cert Chemistry and Leaving Cert Physics into a single course which is examined separately. The students who decide to sit Physics and Chemistry cannot sit Physics or Chemistry as separated subjects. Physics and Chemistry was designed for students who have an interest in both physics and chemistry, but don't have enough time or interest to study both subjects separately.

The number of second-level schools offering the subject has gone from around 200 in 1993 to less than 50 in 2017 (Figure 47), which may explain why the number of students sitting this Leaving Certificate subject has soared tremendously within the past twenty two years.

5.3.9 Computer Studies and Technology

Despite being subjects available at the Senior Cycle, I chose to leave them out of the Results section because Computer Studies have not had an equivalent at the Leaving Certificate exam yet (set to change in 2020 with the introduction of Computer Science) and Technology has only been covered from 2009 onwards - therefore not offering enough data prior to the recession.

It is undeniable that the introduction of Computer Science at the Senior Level was due to the privileged place Ireland finds itself in: the country has an international reputation in key software-based sectors, yet not enough labour supply to meet an ever growing demand, which resulted in a top-down approach from the government. In the latest "Action Plan for Jobs"[12], it is stated that:

> Computer services accounted for almost half (forty seven point two percent) of total services exports in 2016. Goods exports are dominated by medical and pharma products (twenty six point nine percent), organic chemicals (nineteen point one percent) and machinery and transport equipment (fifteen percent).

Not only that, but Ireland is also the second largest exporter of computer and IT services in the world. The country's workforce is highly talented and creative, and alongside a relatively open economy and a competitive corporate tax environment, it has proven to be a hub of information technology in Europe: eight of the top ten global information technology companies have established a significant presence in the Republic.

Apart from the existing fourteen Institutes of Technology, the government has put aside €200 million capital investment under the Public Private Partnership model which will be used to create another eleven Institutes of Technology with 8,000 new student places, primarily in STEM subjects. Referring to the introduction of Computer Science in secondary schools, Ireland's Minister for Education and Skills, Richard Bruton, said that "there is a digital revolution taking place which is having a transformative effect on our economy, workplace, and lifestyle," and "the introduction of (Computer Science) will teach our young people flexible, solution-oriented thinking".

[12] Action Plan for Jobs (2018). Retrieved from https://dbei.gov.ie/en/Publications/Publication-files/Action-Plan-for-Jobs-2018.pdf

The introduction of a new subject is the perfect moment for researchers to develop assessment techniques and to apply substantial evaluation methods. Also, as said by Quinn (2012), “there is a real opportunity for us to utilise the great IT companies that are based in Ireland to facilitate new teaching methodologies” (Quinn, 2012).

5.4 Single-sex schools versus mixed schools

5.4.1 Introduction

A real divisive aspect can be noticed when looking at the Leaving Certificate - Engineering graph (Figure 24): the “boys to girls ratio” is abysmal. The number of boys choosing to sit Engineering is comparatively low if compared to some other STEM subjects like Physics and Applied Mathematics, but no other subject presents such absence of female candidates.

When presented with those results, my supervisor hinted at the fact there are still gender separation in a high number of schools in Ireland. If a school does not offer a certain subject at the Senior Cycle, it follows that a student will not be prepared to sit that subject at the Leaving Certificate exam, therefore will not choose to do so. If there is no demand for the subject starting from the students (due to lack of information and/or disinterest), it is unlikely that a school will offer it any time soon. It is difficult to differentiate between the reasons: is it the lack of demand that drives supply to decrease, or is it the absence of supply that explains the absence of opportunity?

Leaving questionings aside, in order to visualize the progression of STEM subjects being offered at the Senior Cycle in both single-sex and mixed schools, I collected the number of second-level schools in Ireland from 1993 to 2017 that are single-sex schools for “boys only” (“SSS Boys”) and “girls only” (“SSS Girls”), and mixed schools (which, in some cases, also offer classes to boys and girls only).

The graphs for each STEM subject can be found at the Appendices chapter, Appendix A “Single-sex versus mixed Schools”.

5.4.2 Percentage of single-sex schools and mixed schools in Ireland

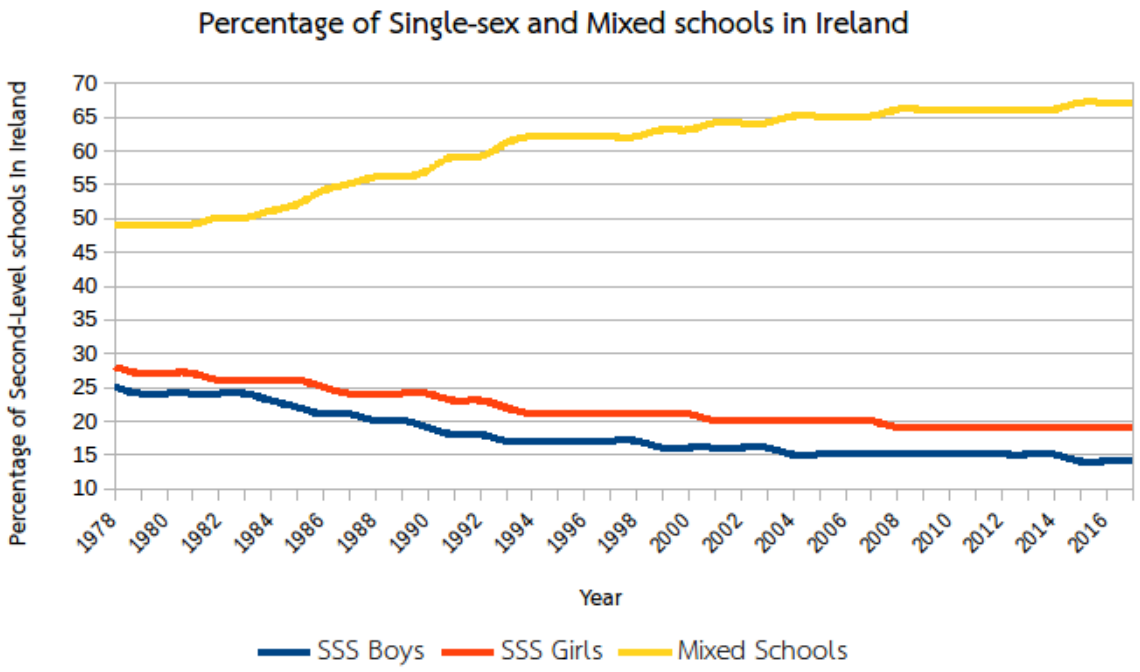


Figure 37 - Percentage of single-sex schools and mixed schools in Ireland

In total, there are more girls-only schools than boys-only schools, and the number of mixed schools is at least twice the number of single-sex schools combined depending on the year analysed.

5.4.3 Discussion

Interestingly enough, the STEM subjects chosen more frequently by girls at the Leaving Certificate are the ones being offered more frequently at girls-only schools if compared to boys-only schools: Biology (Figure 41), Chemistry (Figure 42), and Mathematics (Figure 45). Boys-only schools outnumber girls-only schools in Applied Mathematics (Figure 40), Agricultural Science (Figure 39), and Engineering (Figure 44), which are subjects not so popular with Leaving Certificate female candidates. Insofar as Physics (Figure 46) and Physics and Chemistry (Figure 47) go, the gap between the number of single-sex schools is small, rendering the analysis for these two subjects inconclusive.

Not only is there a separation based on gender between schools but also within schools. As mentioned before, there are mixed-schools which offer certain subjects to a certain gender

only. If these are public schools, a deeper investigation is required; if not, investigation is advised but parents and school boards still have the last word.

Studies on the question of gender-separation in schools have presented different results depending on where they were realised. In Seoul, Sohn (2016) found that "on average, the positive effects of single-sex schooling on test scores are small, especially when the parental and teacher sorting are accounted for" (Sohn, 2016); in Switzerland, Eisenkopf, Hessami and Fischbacher's study showed that "single-sex schooling improves the performance of female students in Mathematics" and such positive effect is particularly large for female students with high ex-ante ability (Eisenkopf, Hessami and Fischbacher, 2014).

In Ireland, Prendergast and O'Donoghue (2014) found that girls in single sex schools performed better in Mathematics and enjoyed the subject more than girls in co-educational schools (Prendergast and O'Donoghue, 2014). Belenky et al. (1986) argues that such a learning environment gives females a space for themselves where their voices are heard and their ways of thinking and learning are acknowledged and valued (Belenky et al., 1986).

Generally speaking, it is not only about grades: there is no major difference between girls grades whether they study solely with other girls or with girls and boys, but boys hugely benefit from social interactions with girls in comparison to when they go to a boys-only school. These effects and their psychological aspects are beyond the scope of this study, but it is something to be considered when making the case for either (or neither) type of school. What deserves to be highlighted is the fact Ireland has an incredible amount of primary and secondary schools for such a small population. As pointed out by Quinn,

> (...) resources can be underutilized, duplicated or badly allocated, particularly at post-primary level. We have to ensure the optimum use of resources, both human and physical, through structured cooperation between schools, especially at post-primary. The transformation of the education system should aim to enhance the quality of the educational experience of all its students, while achieving value for money. This is necessary if we are to maintain an education system which holds the confidence and respect of Irish citizens and taxpayers. (Quinn, 2012).

The shortage of STEM teachers at secondary-education in Ireland in well-known, with yearly calls from the DES for more STEM graduates to undergo a professional master's degree in education, which would allow them to teach at second-level schools. For the past years, more college courses were particularly designed and created aiming at increasing the numbers of

Physics, Chemistry and Mathematics teachers, but not even financial incentives are good enough. Ireland spends a high percentage of public funding on primary to post-secondary education (the highest percentage in Europe), according to data from the OECD. So if there is a substantial amount of money being directed at a great number of schools, and there has been no considerable improvement in twenty two years when it comes to engaging students in almost half the subjects being taught at those schools, then certainly an assessment on the effectiveness of Irish schools in enhancing students' human capital - which is the basis for any productive labour market - is necessary.

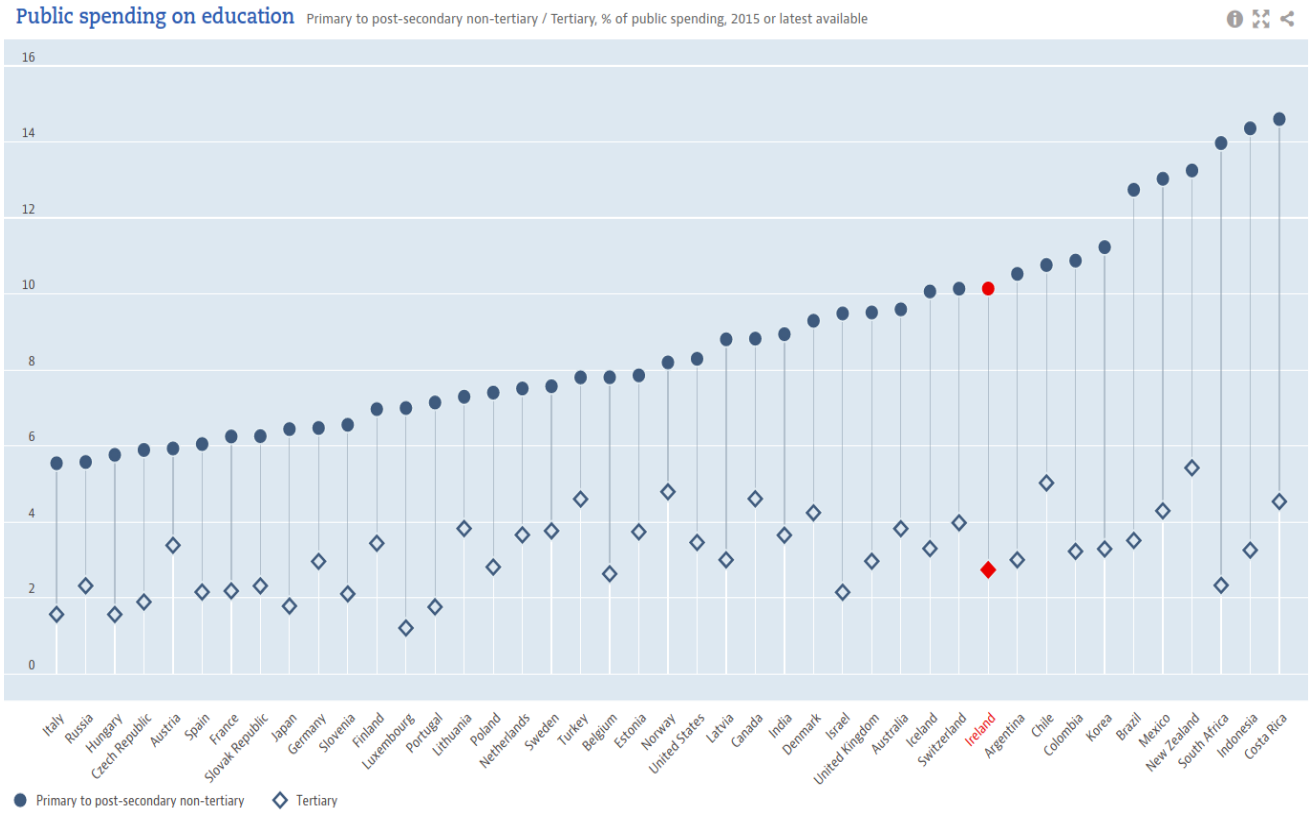


Figure 38 - OECD's public spending on education[13]

5.5 Universities and STEM courses

My initial hypothesis might have been proven inconclusive, and when I mentioned it to my supervisor, he suggested I should look at the points necessary to enter a couple of Science and Engineering courses at third-level institutions. We found that the number of points

[13] Public spending on education: Primary to post-secondary tertiary, % of GDP (2013 – 2016). Retrieved from https://data.oecd.org/eduresource/public-spending-on-education.htm

necessary for admission at those courses increased a good amount in 2008 and after, which lead us to think that maybe we were looking in the wrong place.

There are seven main Universities in Ireland and fourteen Institutes of Technology, but these are not the only higher-level institutions, so tracing each STEM course for every higher-level institution would take a long time and it would be off the main objective of this study. Because of this, we decided to map the principal STEM courses offered by the seven universities only, and we considered solely the courses which were created prior to the recession. It is worth mentioning many more STEM courses were created since then, and it would be of great value to analyse the exact number, the number of candidates who applied for them, break the numbers between males and females, and other variables.

All the graphs related to the seven Irish Universities can be found at the Appendices chapter, Appendix B "Universities and STEM courses". The reader will notice an overall trend for all universities: in average, admission for STEM courses started to be more difficult from 2008 onwards. Students must perform better and achieve more points in relation to their counterparts who sat the Leaving Certificate prior to the financial crisis. This trend reflects an interesting dichotomy: whereas not all STEM subjects are being sought more frequently after the financial crisis, more students are deciding to pursue STEM-related majors. It would be interesting to see this phenomena being studied in dept.

5.5.1 Dublin City University (DCU)

DCU offers fourteen courses directly related to STEM areas, and all of them had their admission points increased by a great amount from 2008 onwards.

5.5.2 Maynooth University

Maynooth University ranks second at the lowest number of STEM courses of all universities, but all of them also presented a considerable increase in necessary points from 2008 to 2016.

5.5.3 National University of Galway (NUIG)

NUIG is greatest - in numbers - higher-level institution in county Galway also saw a spike all admission points for the majority of its STEM courses, especially for Science.

5.5.4 University of Dublin - Trinity College (TCD)

TCD is Ireland's most prestigious University and it is famous for its competitive admission process, which includes a fair amount of STEM courses. In 2016, the number of points for all STEM courses hit the minimum of 470, with Nanoscience and Dental Science hitting almost 600.

5.5.5 University College Cork (UCC)

University College Cork also saw an increase in the necessary points for admission at all its STEM courses starting and 2008 and steadily progressing until 2016.

5.5.6 University of Limerick (UL)

UL also experienced an increase in the admission points for its STEM courses, comparatively fewer than the other universities, but pronounced nonetheless.

5.5.7 University College Dublin (UCD)

UCD is one of the most innovative universities in Ireland, and this fact reflects on its numbers. In general, from less than 350 points in 2005 to more than 450 points in 2016, it is getting more difficult to be admitted to UCD's STEM courses.

6. Conclusion

I had the chance to talk with Professor Deirdre Mccloskey twice in the last two years. The first time, I asked her "do you have any advice on how to effectively motivate students into science?" to which she answered, kindly, "darling, your efforts will only bring them to a certain point. From there, it is up to them to calculate the trade-offs of choosing what and

how to study. The environment in which they find themselves right now will affect their actions in many years to come. Think about it." The second time we met, I told her about this dissertation and what I was hoping to find. She had only one comment: "not all of us will tell you the truth; trust your data, and make sure to remember: people often do not know they are thinking and planning ahead, but they are, it is our instinct. We survive."

The three questions I wanted to answer with this study were not proposed at the same time: they appeared naturally as the data were analysed. First, did the economic recession in Ireland have any impact on students choosing STEM subjects in school? Somewhat yes, it did.

The effects may appear years after the recession. Due to how the education system in Ireland is structured, students are not expected to make decisions "on the spot". What they will study in college is a decision that culminates from years of preparation. I found that, in overall, there was an increase in the numbers of students choosing to sit some STEM subjects at the Leaving Certificate from 2008 onwards. This increase was not abrupt nor in great scale, and there was even STEM subjects being less sought in comparison to others. Because of these findings, there was a necessity to further the study to third-level admissions.

Did the economic recession in Ireland have any impact on students choosing STEM courses in Irish universities? Yes, somewhat it did. In this case, the numbers told a more reliable story and it was easy to spot spikes on the admission points for several STEM courses at the seven Irish universities.

Does the fact that there are still single-sex schools in Ireland contribute to the gender disparity observed at Leaving Certificate subject choices? Yes, it does. This question was proposed more out of curiosity than out of any correlation between the recession and the choice for STEM subjects. Because the DES provides data in relation to the gender of candidates, I decided to see if a trend I learned about before could be the case for Ireland as well: girls go for Biology, boys go for Physics. The reasons why this happen are diverse, and such fact would benefit educators and policy makers if an in-depth study was to be conducted.

I like to think Professor Mccloskey understands the human mind better than I do, and that I lived up to her advice. There is room for investigation in all of the findings of this study. The

road to effective science education depends on what one chooses to consider “effective” and how one chooses to work with others in order to find common ground. We all gain when innovation has space to grow and develop according to society’s needs at the time. Science rewards effort and perseverance, and it is up to us to show the next generation how.

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Appendices

A. Single-sex versus mixed Schools

A.1 Agricultural Science

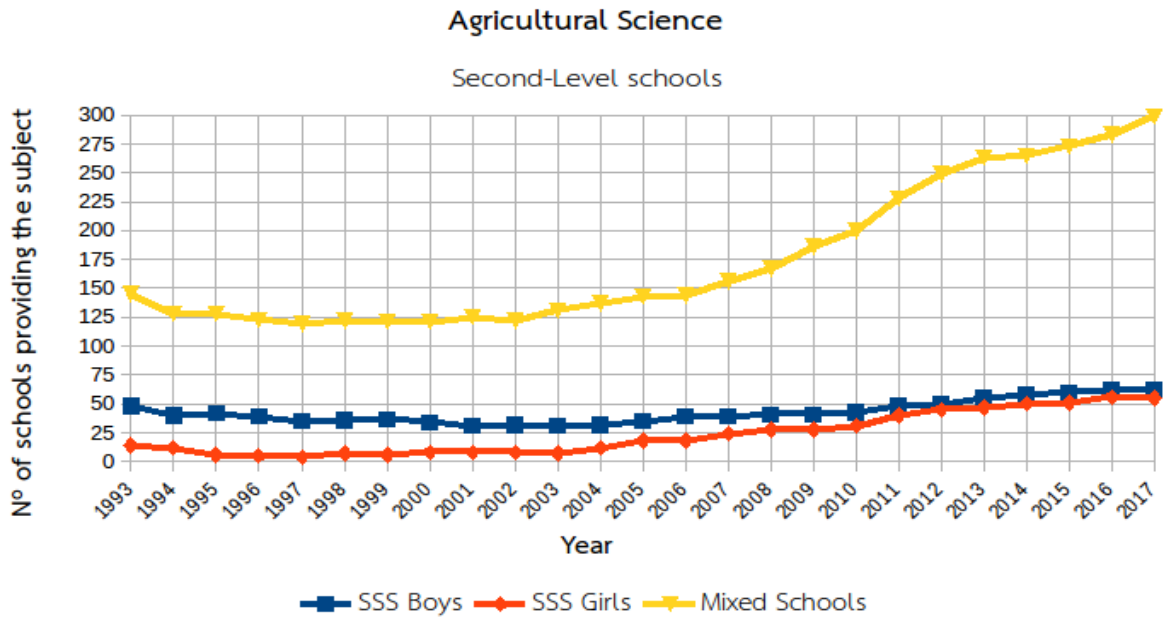

Figure 39 - Agricultural Science: Single-sex Schools versus Mixed Schools

A.2 Applied Maths

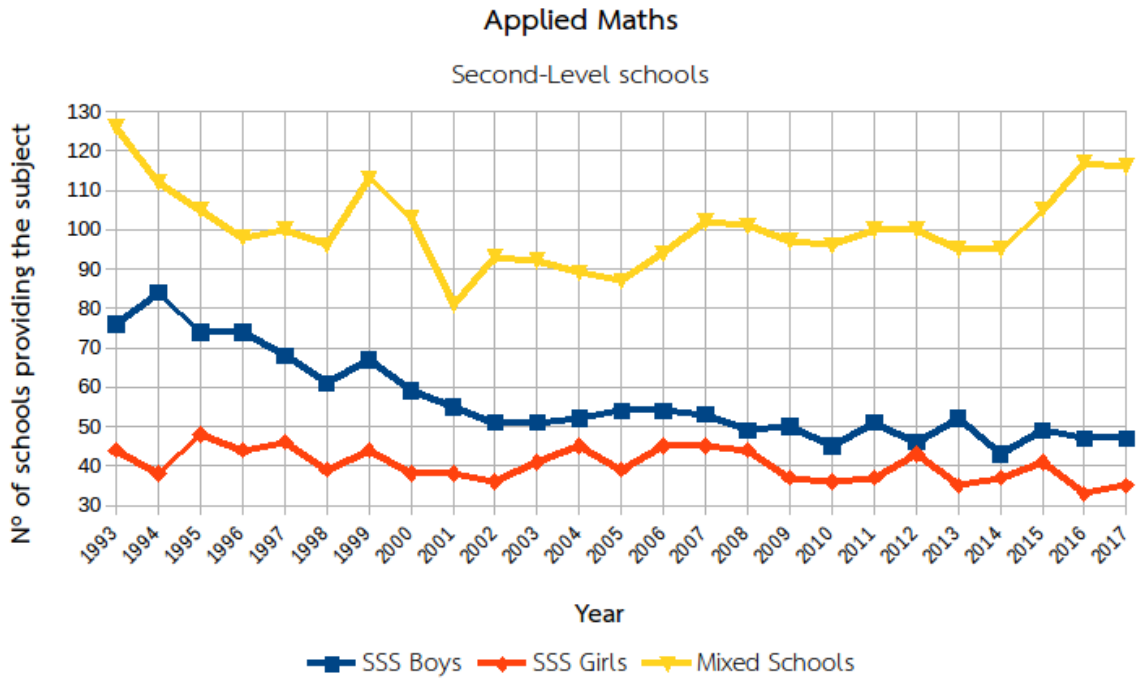

Figure 40 - Applied Mathematics: Single-sex Schools versus Mixed Schools

A.3 Biology

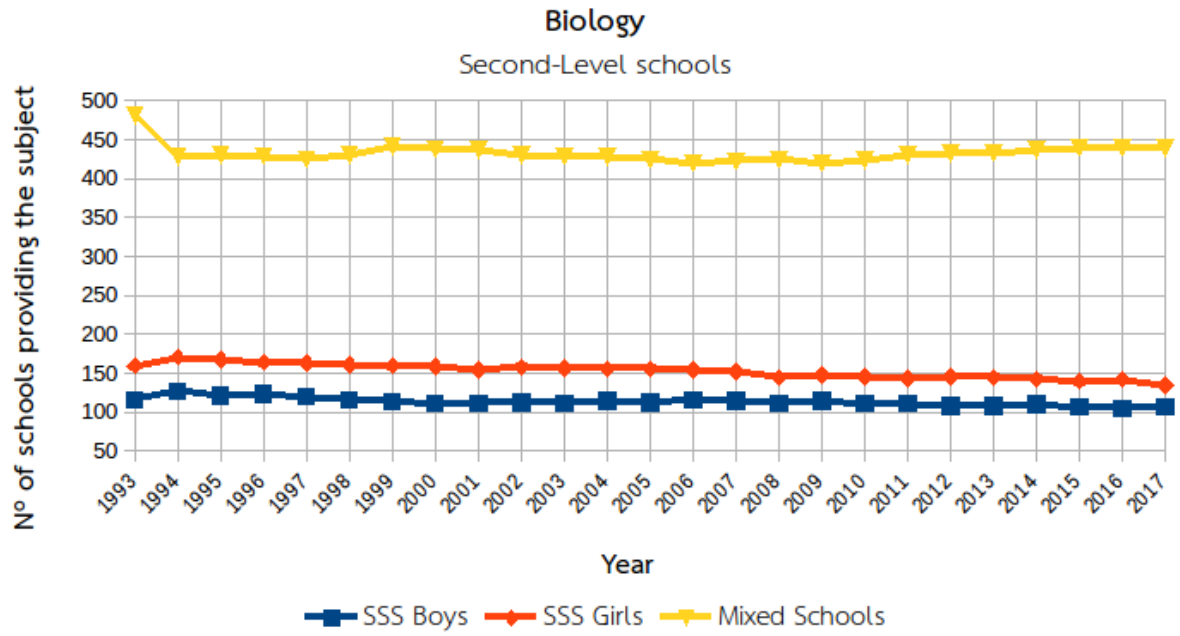

Figure 41 - Biology: Single-sex Schools versus Mixed Schools

A.4 Chemistry

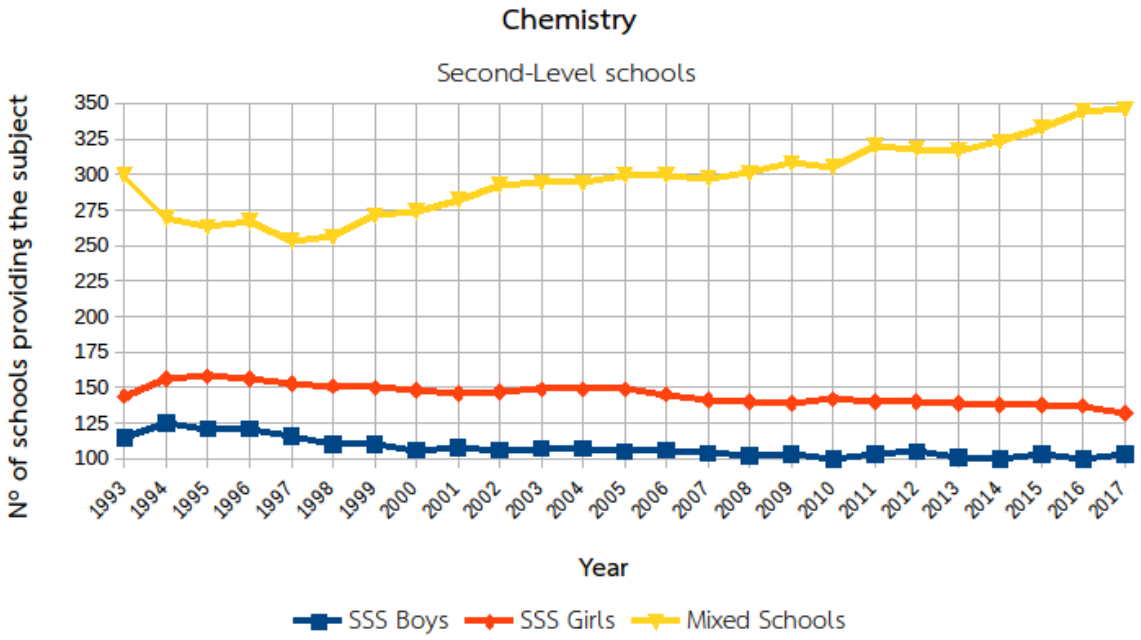

Figure 42 - Chemistry: Single-sex Schools versus Mixed Schools

A.5 Computer Studies

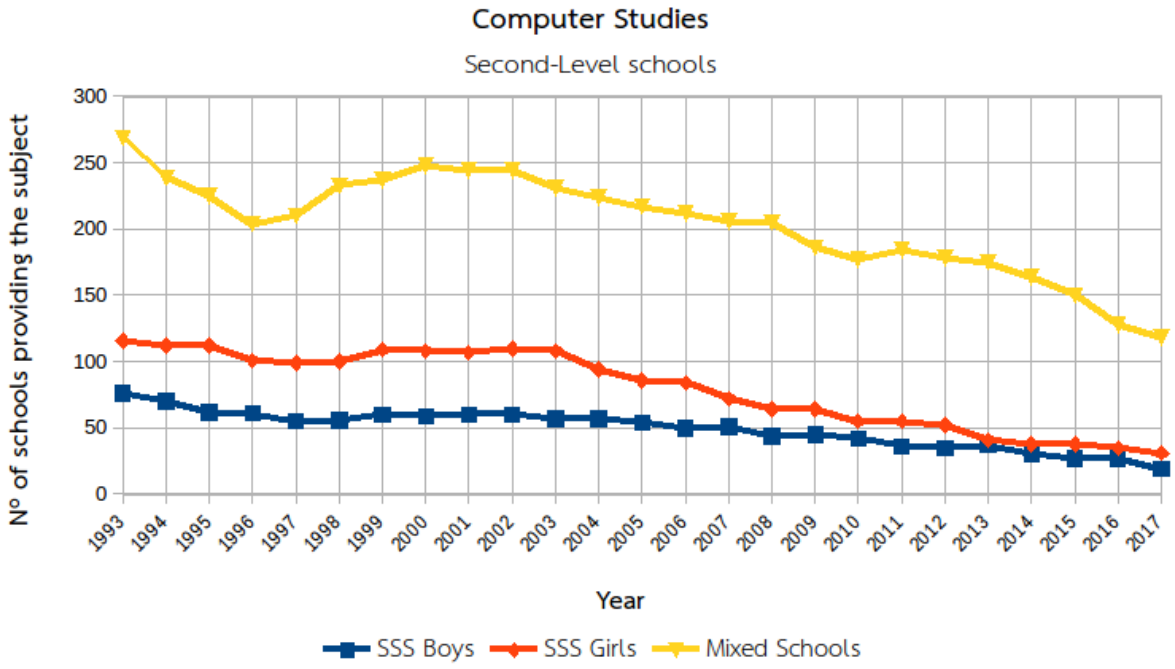

Figure 43 - Computer Studies: Single-sex Schools versus Mixed Schools

A.6 Engineering

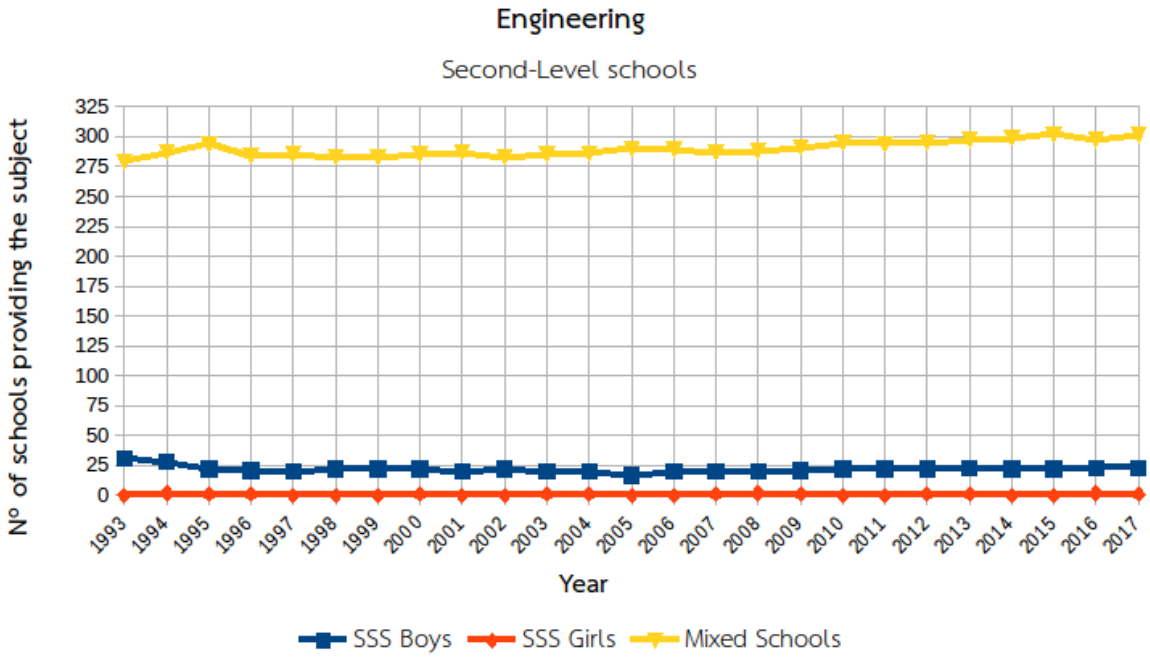

Figure 44 - Engineering: Single-sex Schools versus Mixed Schools

A.7 Mathematics

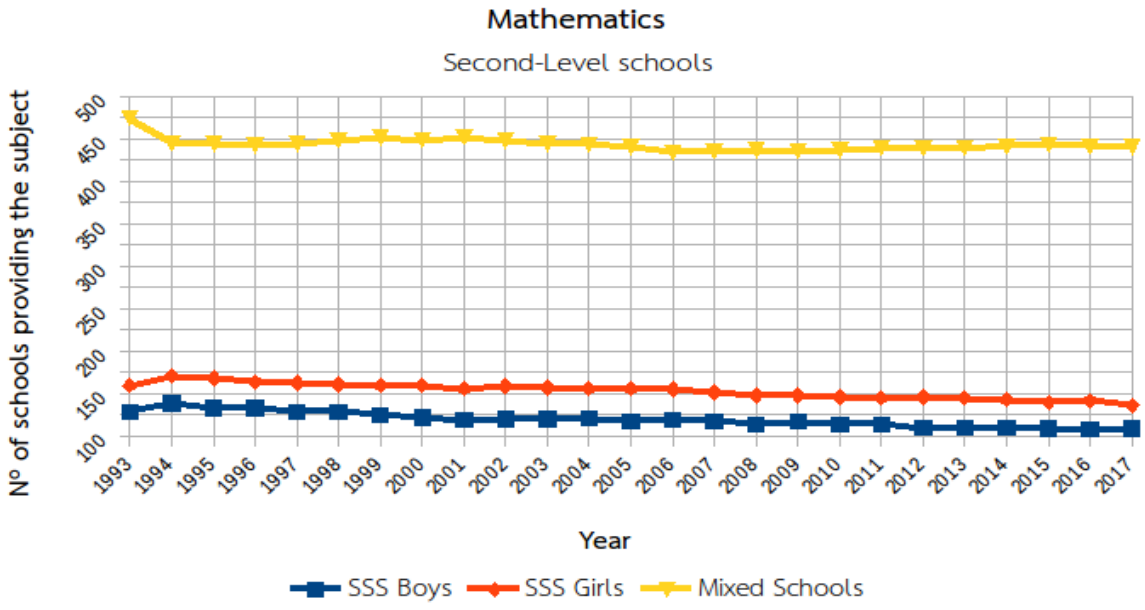

Figure 45 - Mathematics Single-sex Schools versus Mixed Schools

A.8 Physics

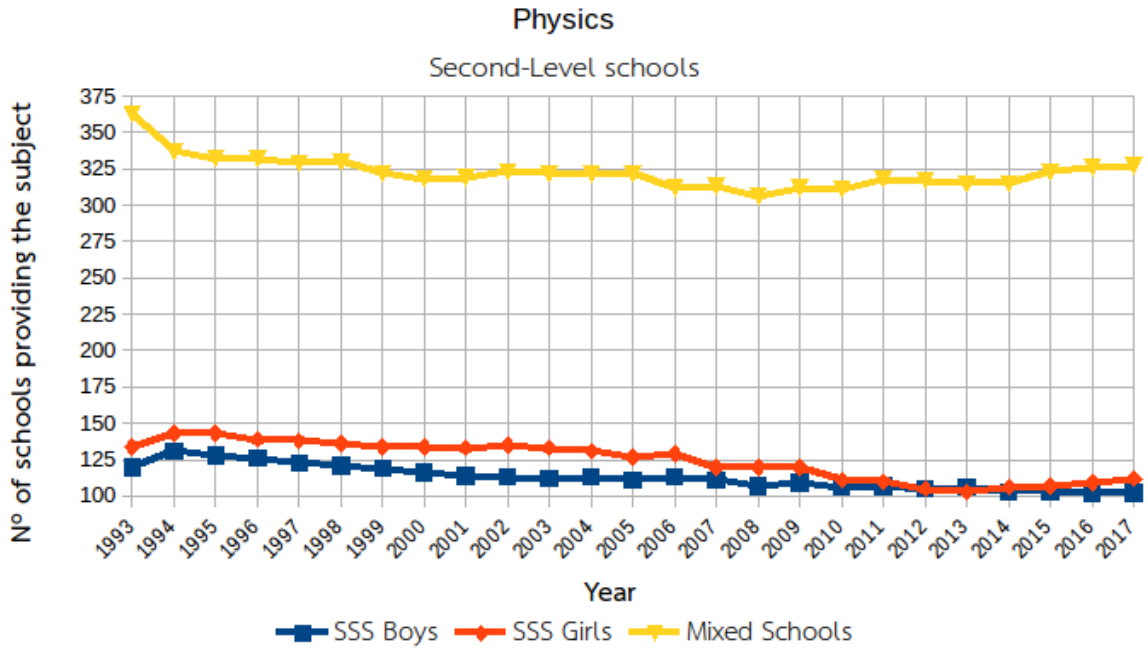

Figure 46 - Physics: Single-sex Schools versus Mixed Schools

A.9 Physics and Chemistry

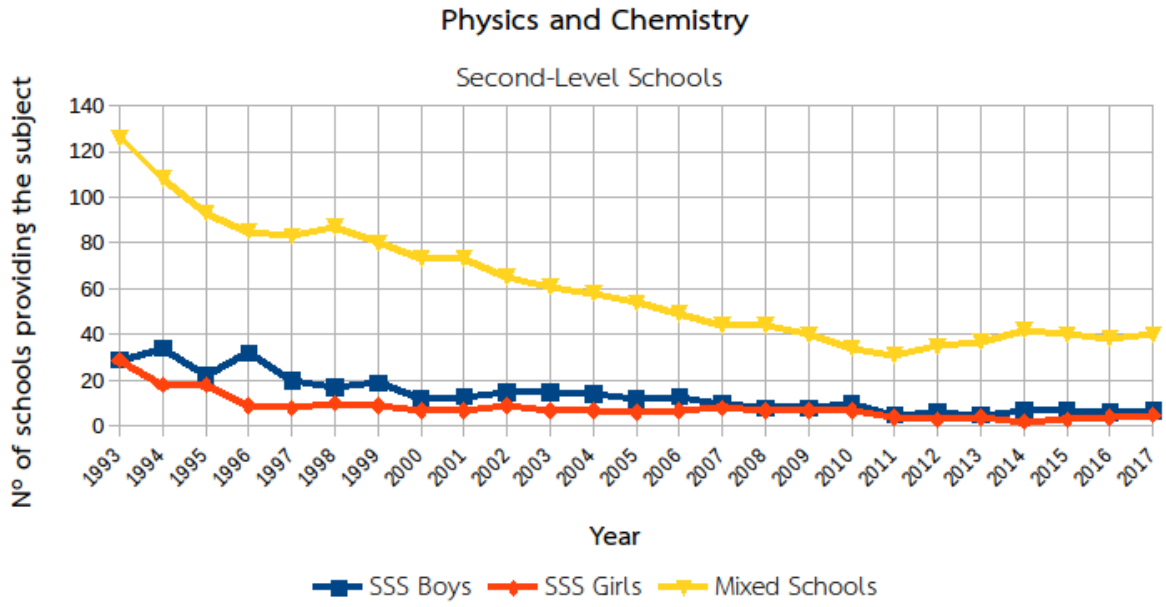

Figure 47 - Physics and Chemistry: Single-sex Schools versus Mixed Schools

B. Universities and STEM courses

B.1 Dublin City University (DCU)

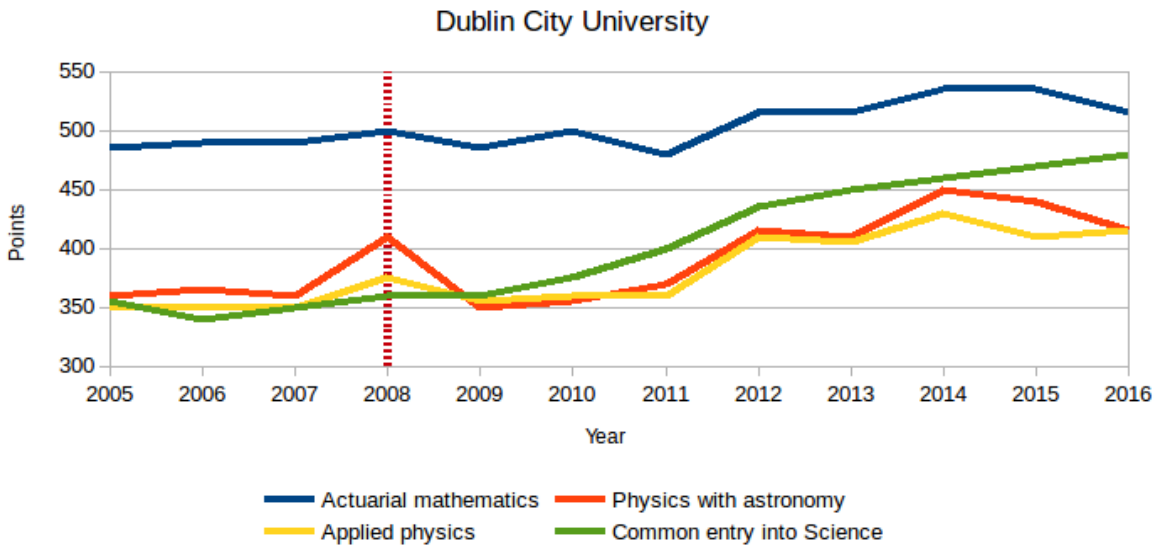

Figure 48 - Dublin City University: STEM courses

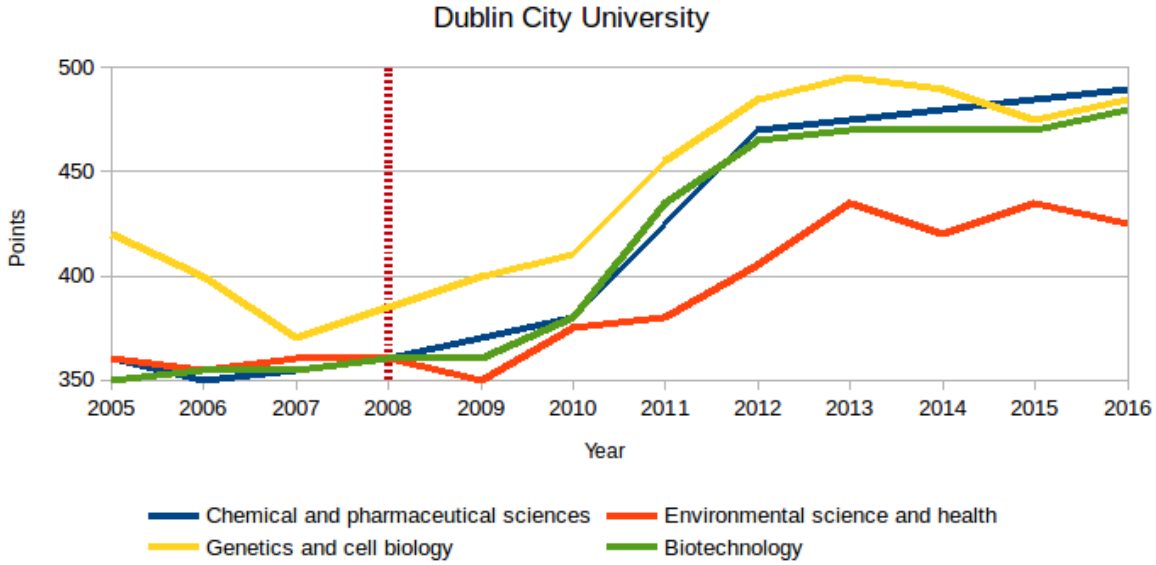

Figure 49 - Dublin City University: STEM courses

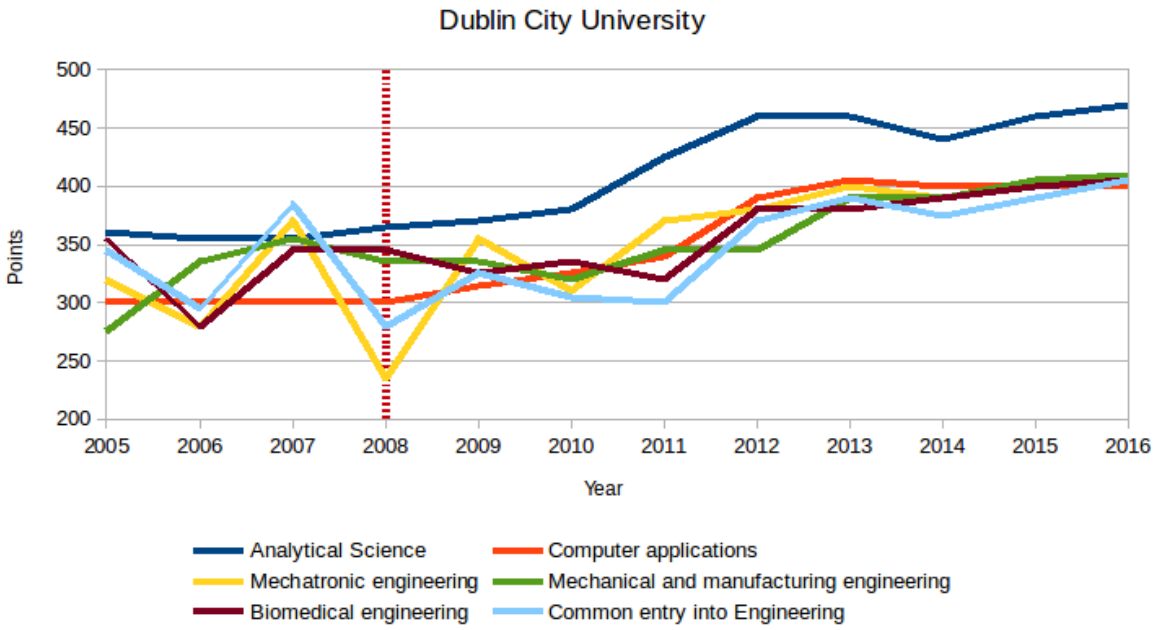

Figure 50 - Dublin City University: STEM courses

B.2 Maynooth University

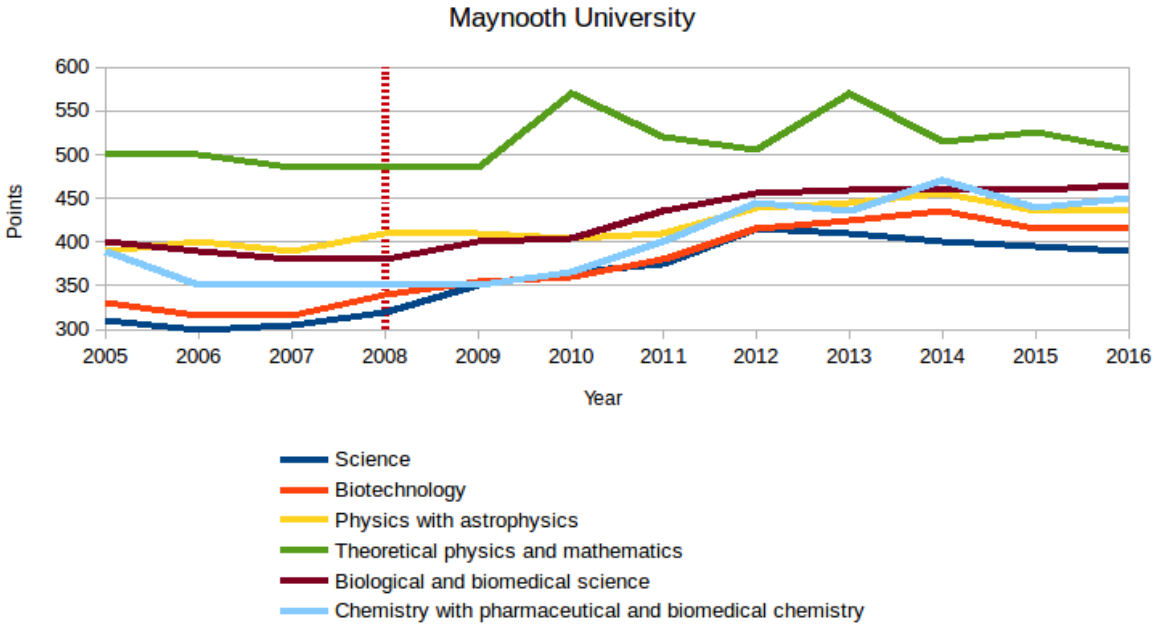

Figure 51 - Maynooth University: STEM courses

B.3 National University of Ireland Galway (NUIG)

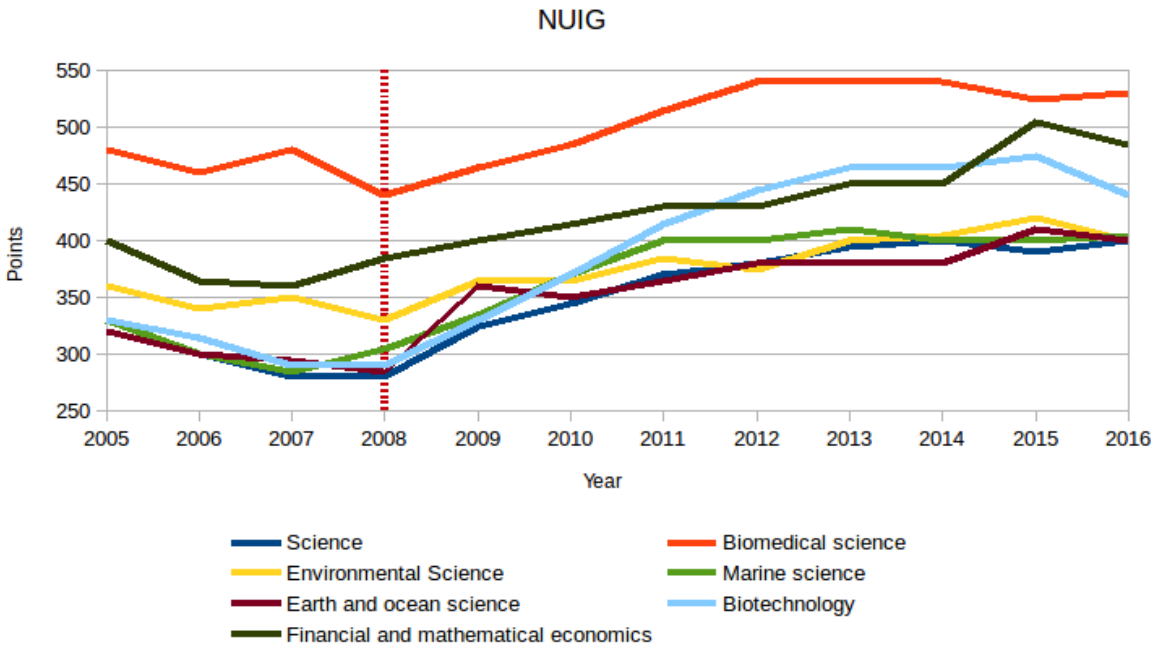

Figure 52 - National University of Ireland Galway: STEM courses

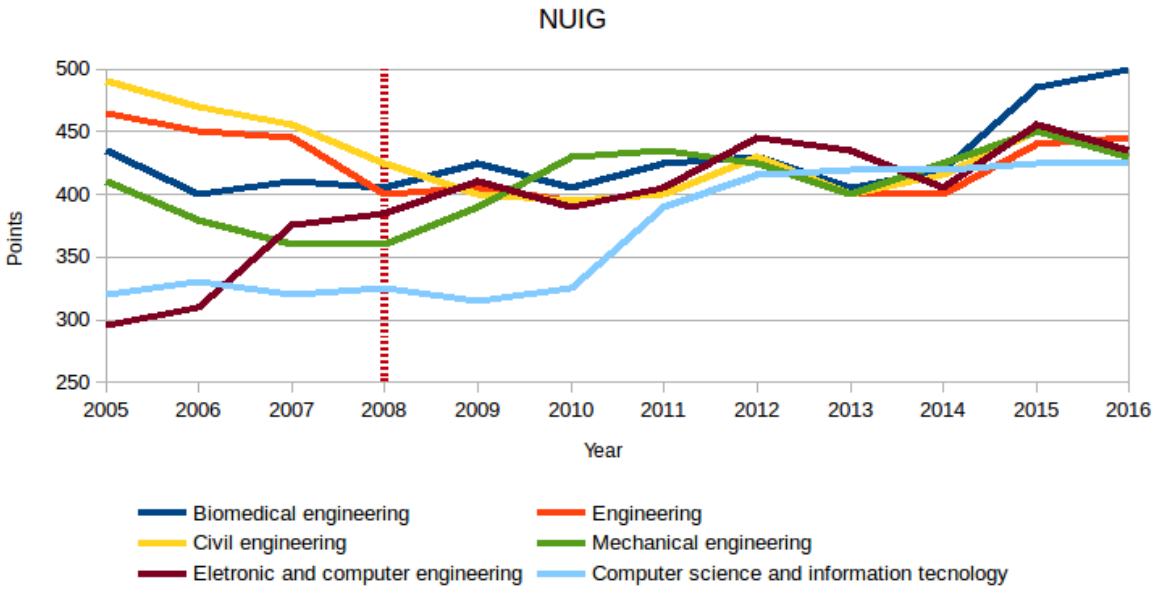

Figure 53 - National University of Ireland Galway: STEM courses

B.4 University of Dublin, Trinity College (TCD)

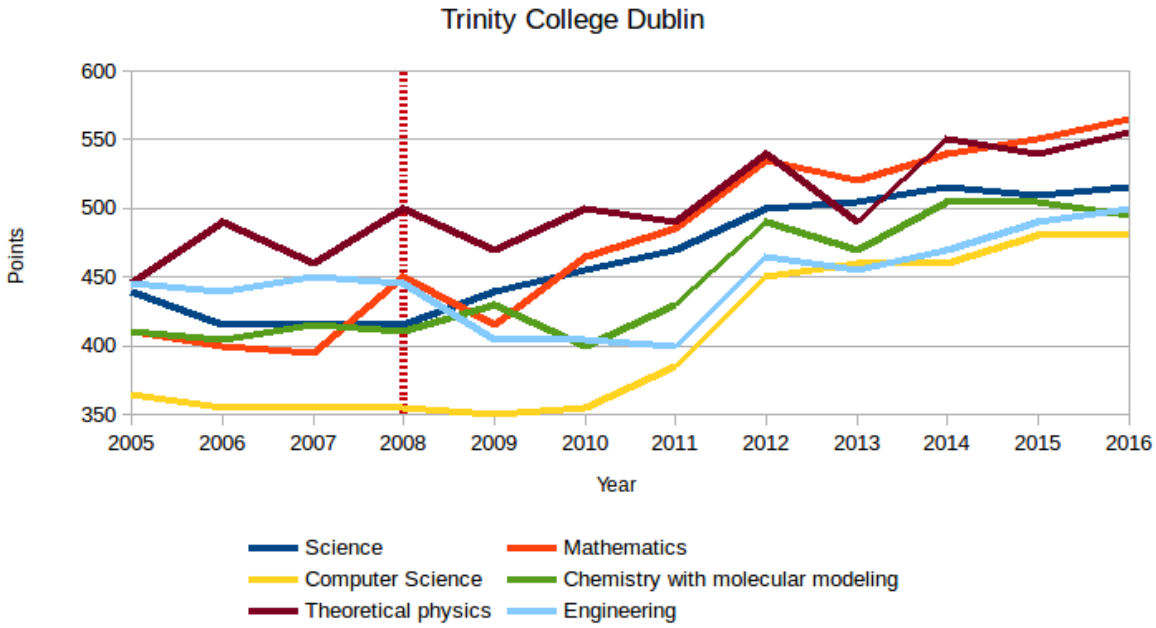

Figure 54 - University of Dublin, Trinity College: STEM courses

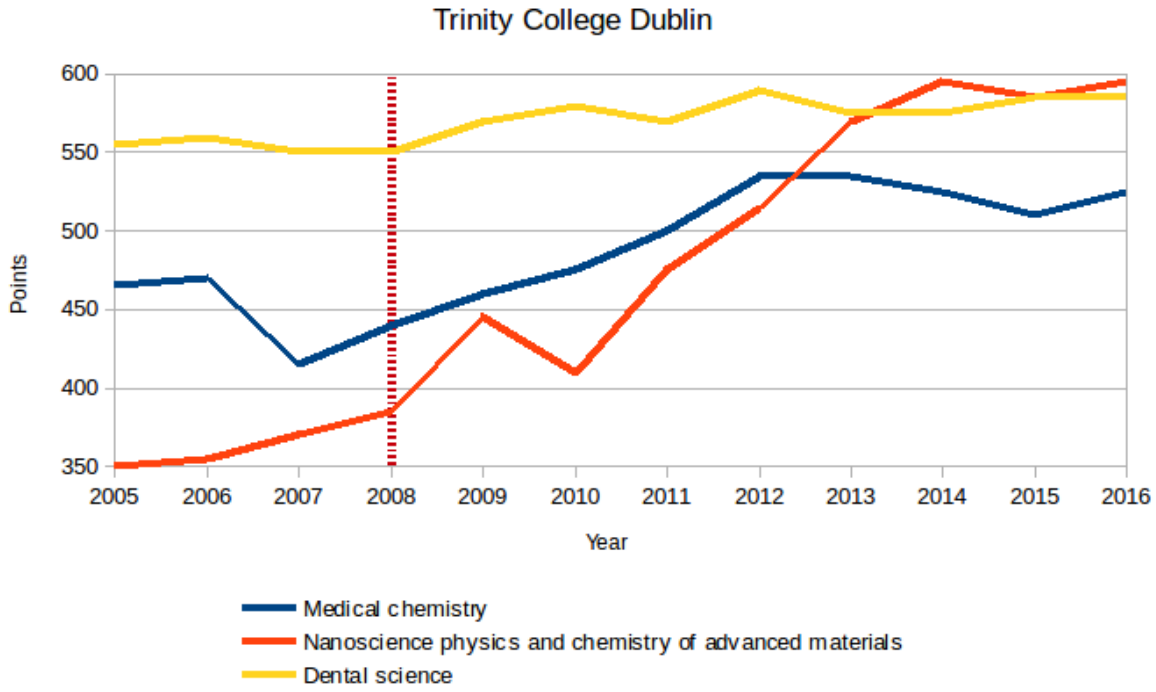

Figure 55 - University of Dublin, Trinity College: STEM courses

B.5 University College Cork (UCC)

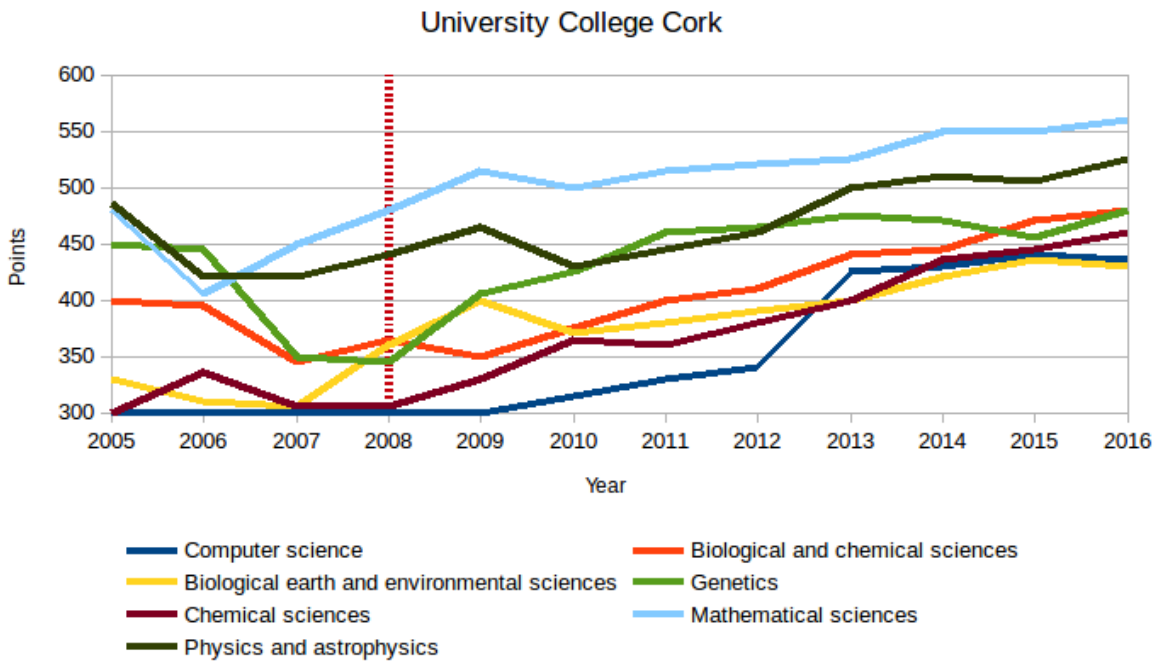

Figure 56 - University College Cork: STEM courses

B.6 University of Limerick (UL)

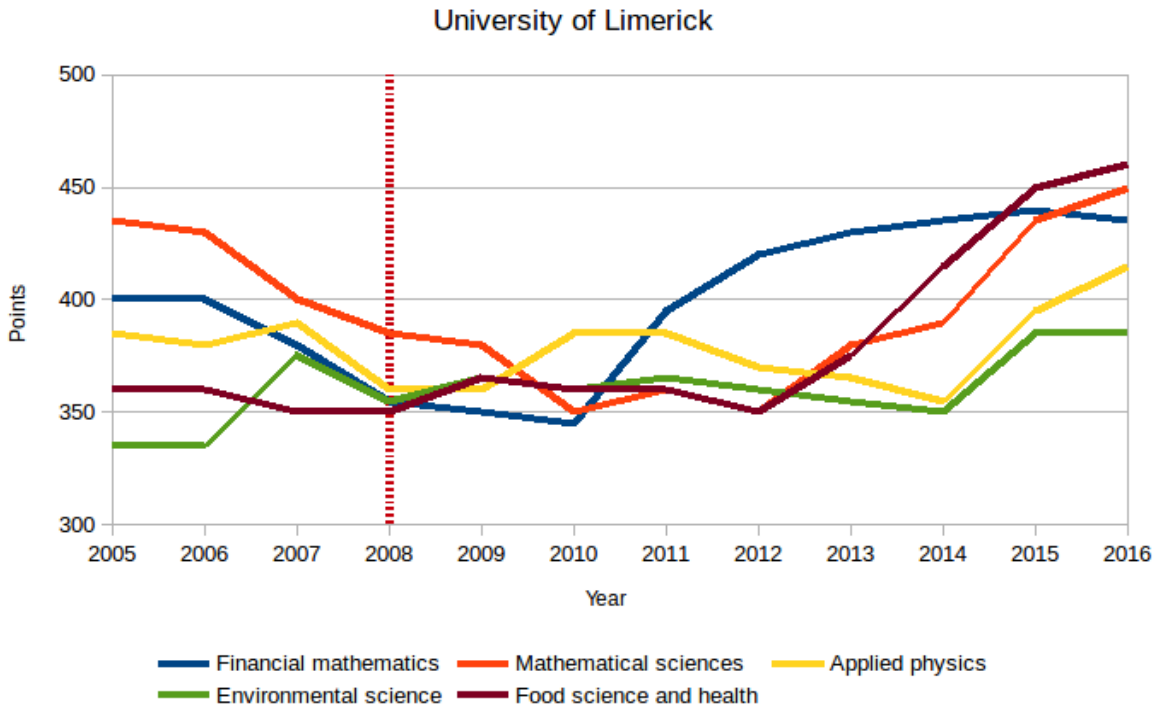

Figure 57 - University of Limerick: STEM courses

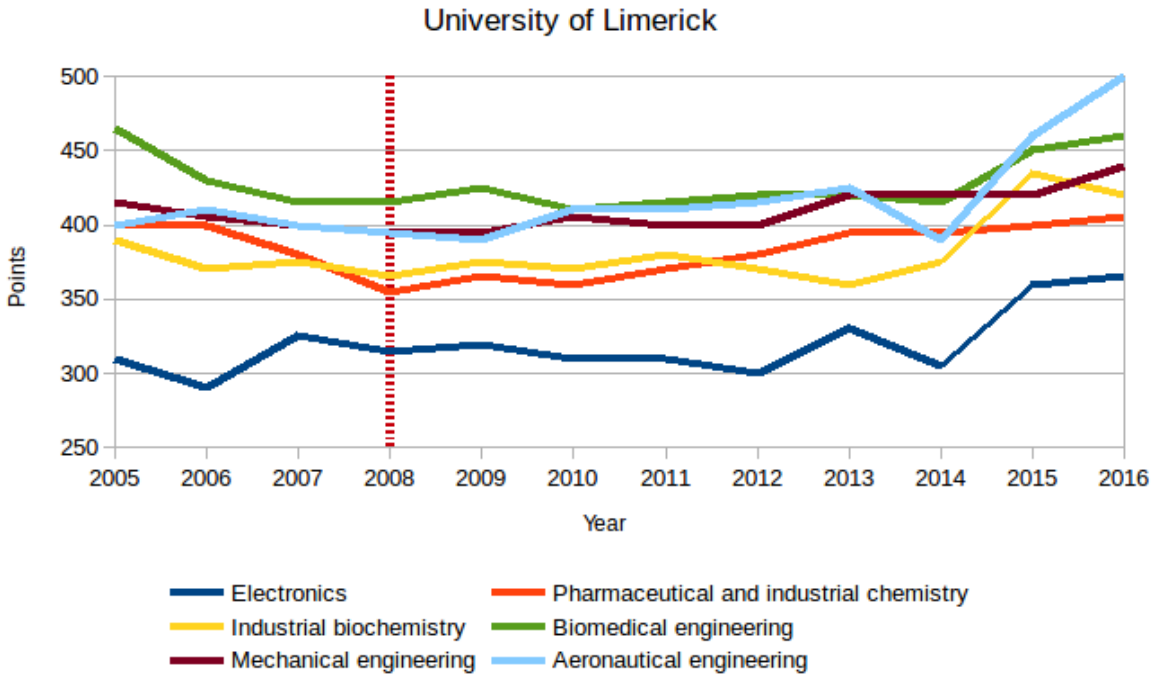

Figure 58 - University of Limerick: STEM courses

B.7 University College Dublin (UCD)

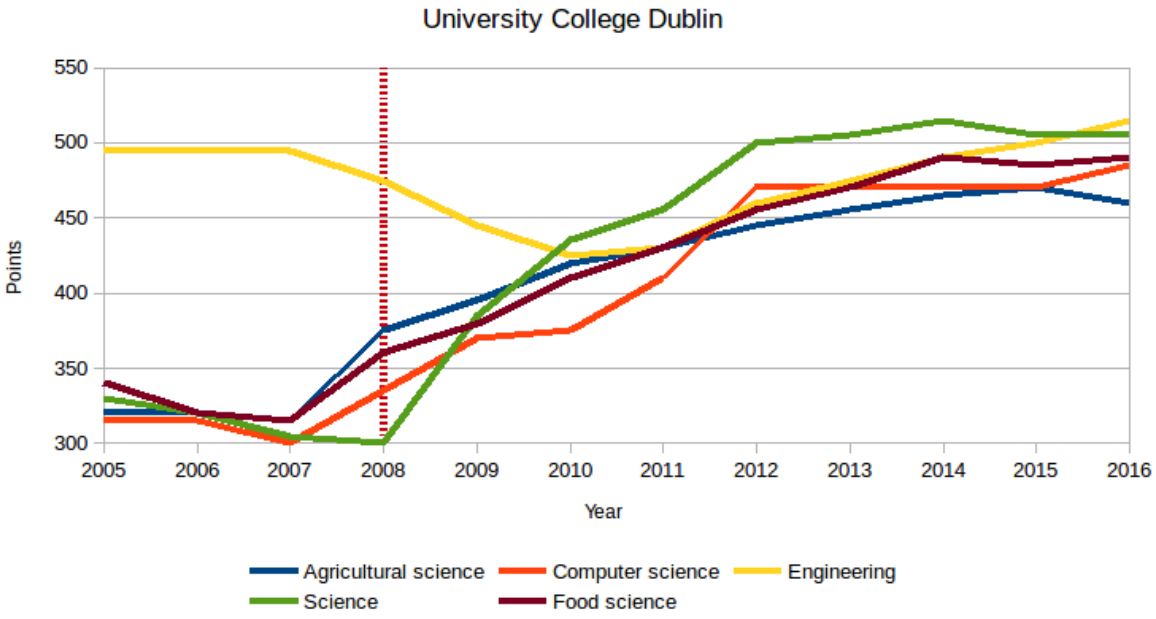

Figure 59 - University College Dublin: STEM courses

C. Leaving Certificate Non-STEM subjects

C.1 Art

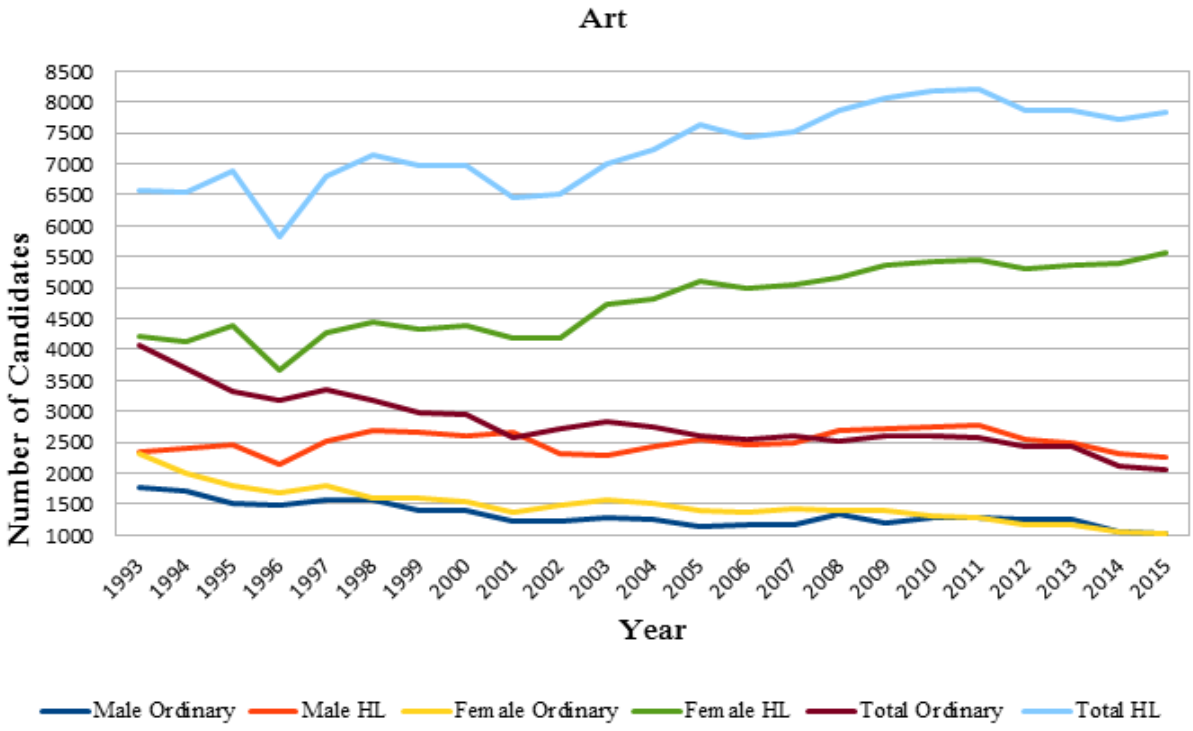

Figure 60 - Art: Leaving Certificate overall

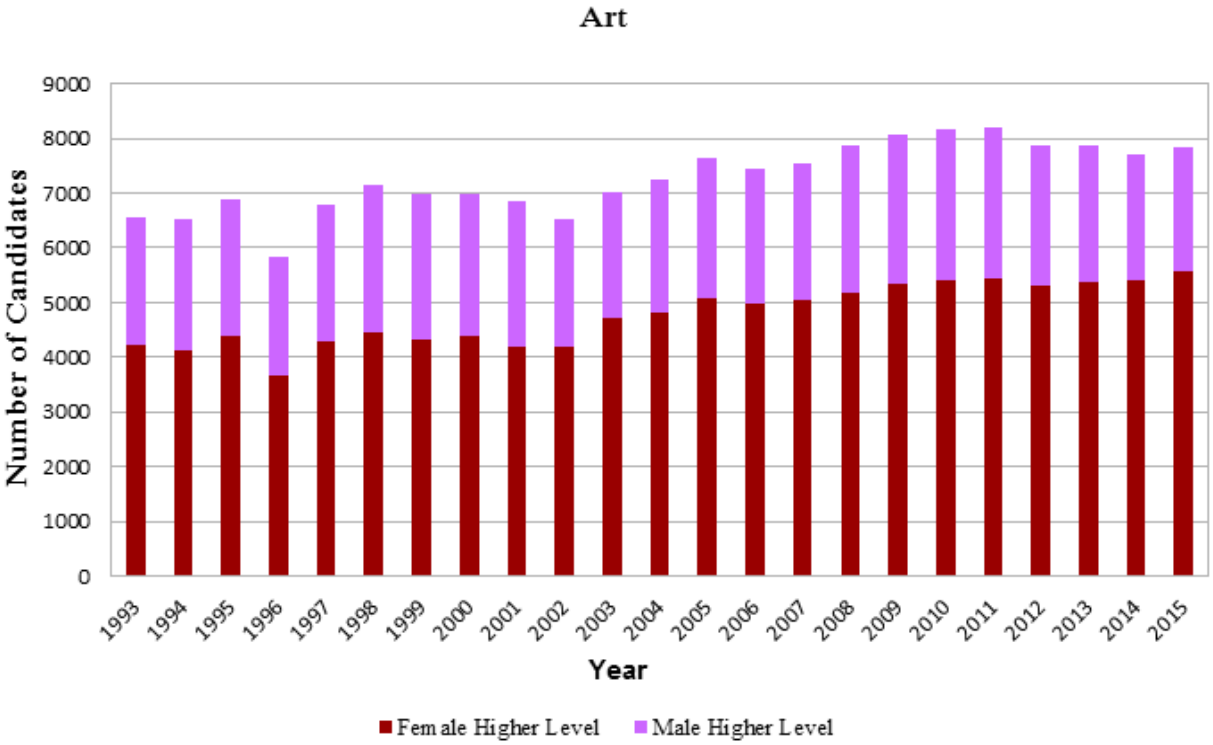

Figure 61 - Art: Leaving Certificate Female and Male Higher Level

C.2 Business

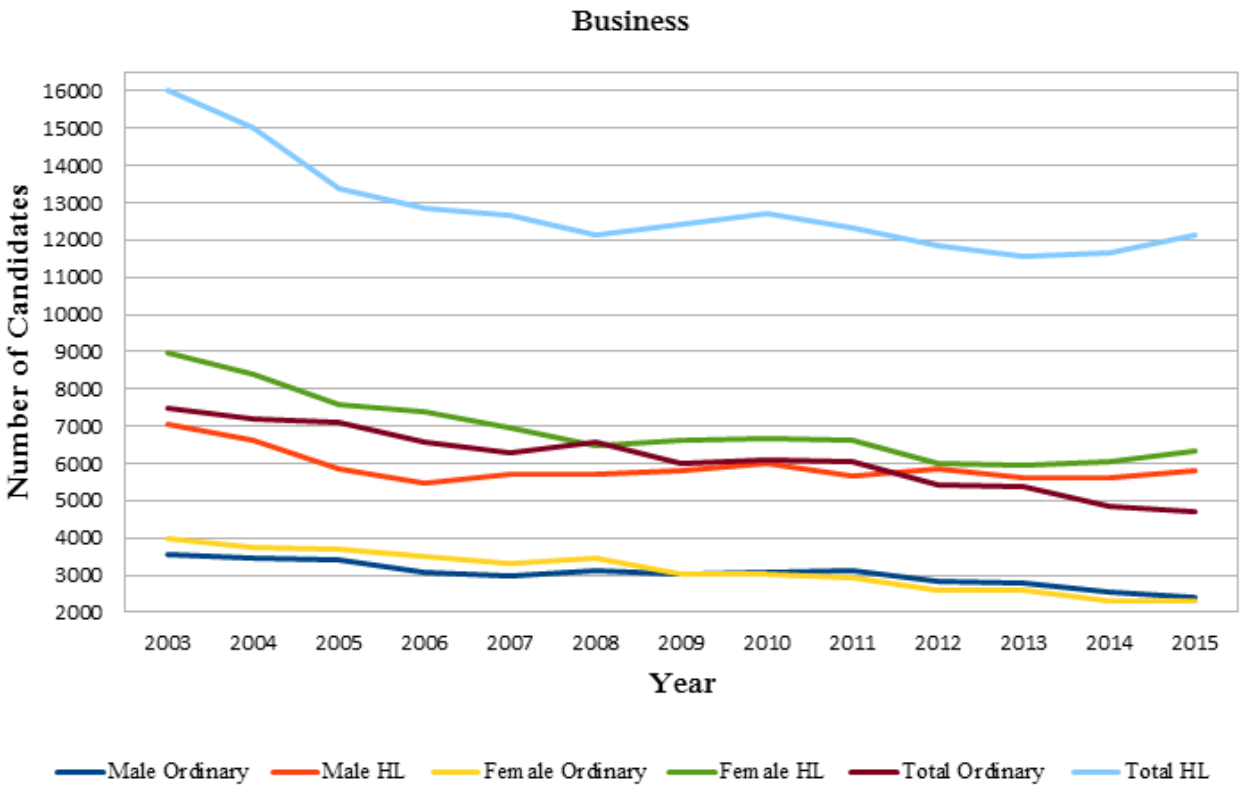

Figure 62 - Business: Leaving Certificate overall

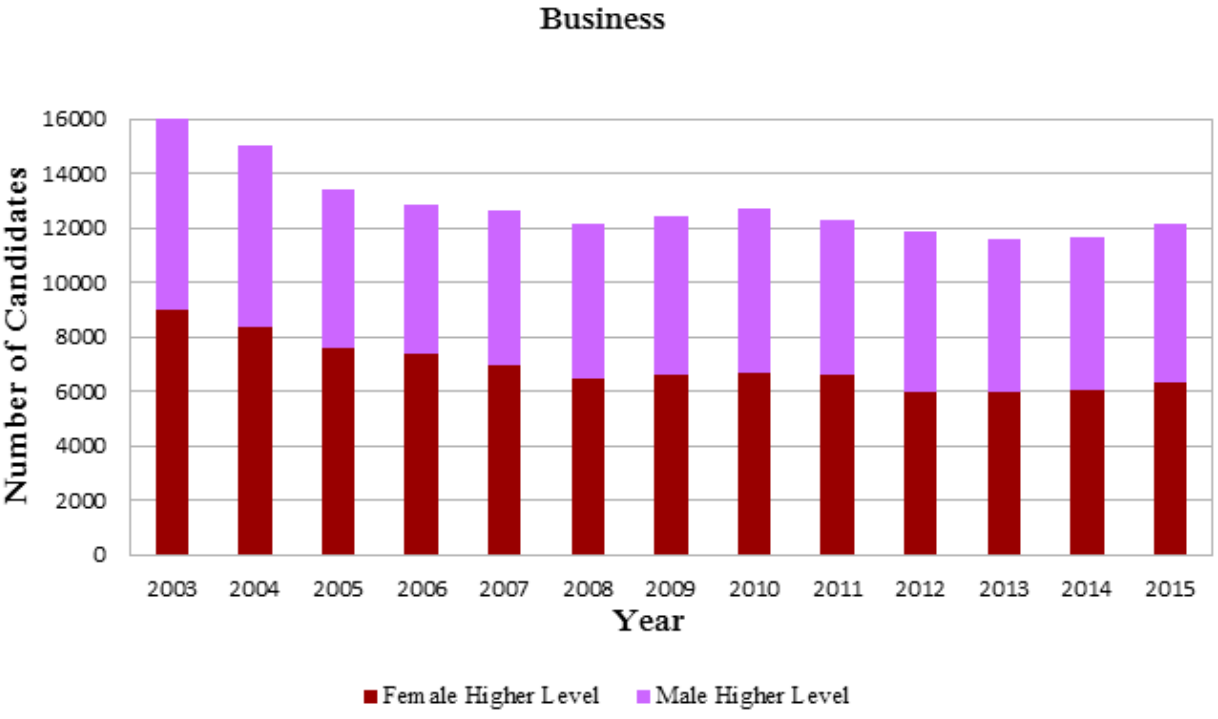

Figure 63 - Business: Leaving Certificate Female and Male Higher Level

C.3 Economics

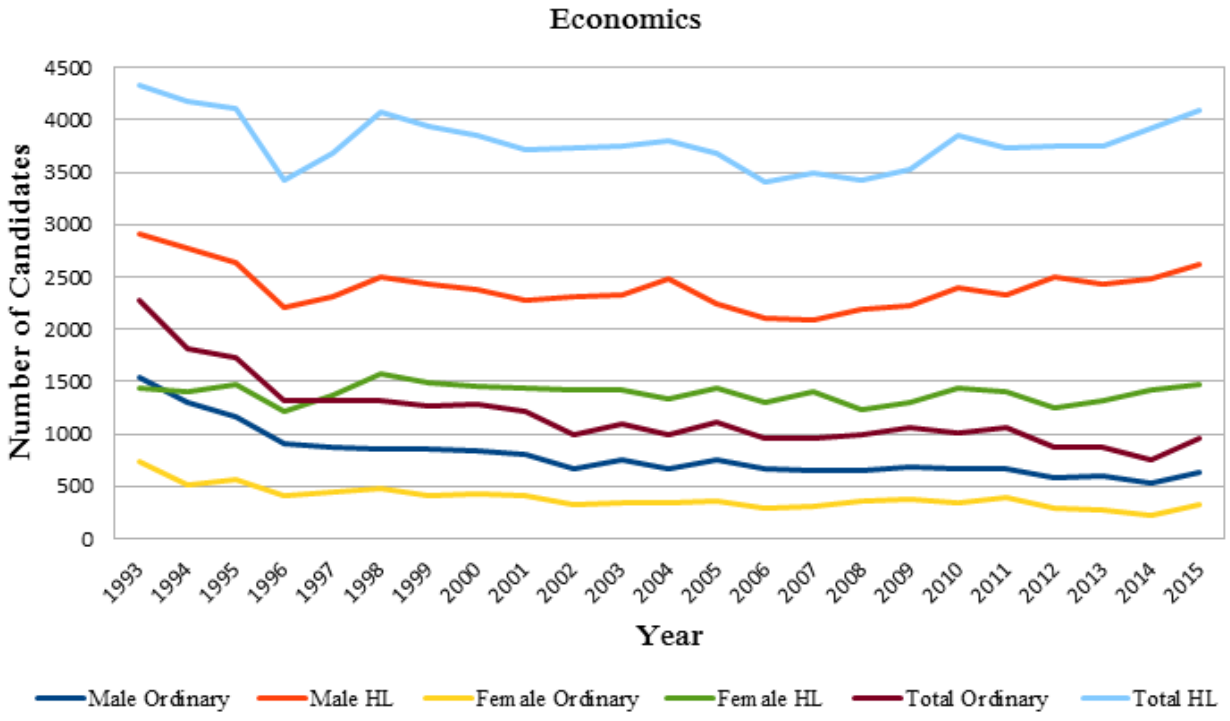

Figure 64 - Economics: Leaving Certificate overall

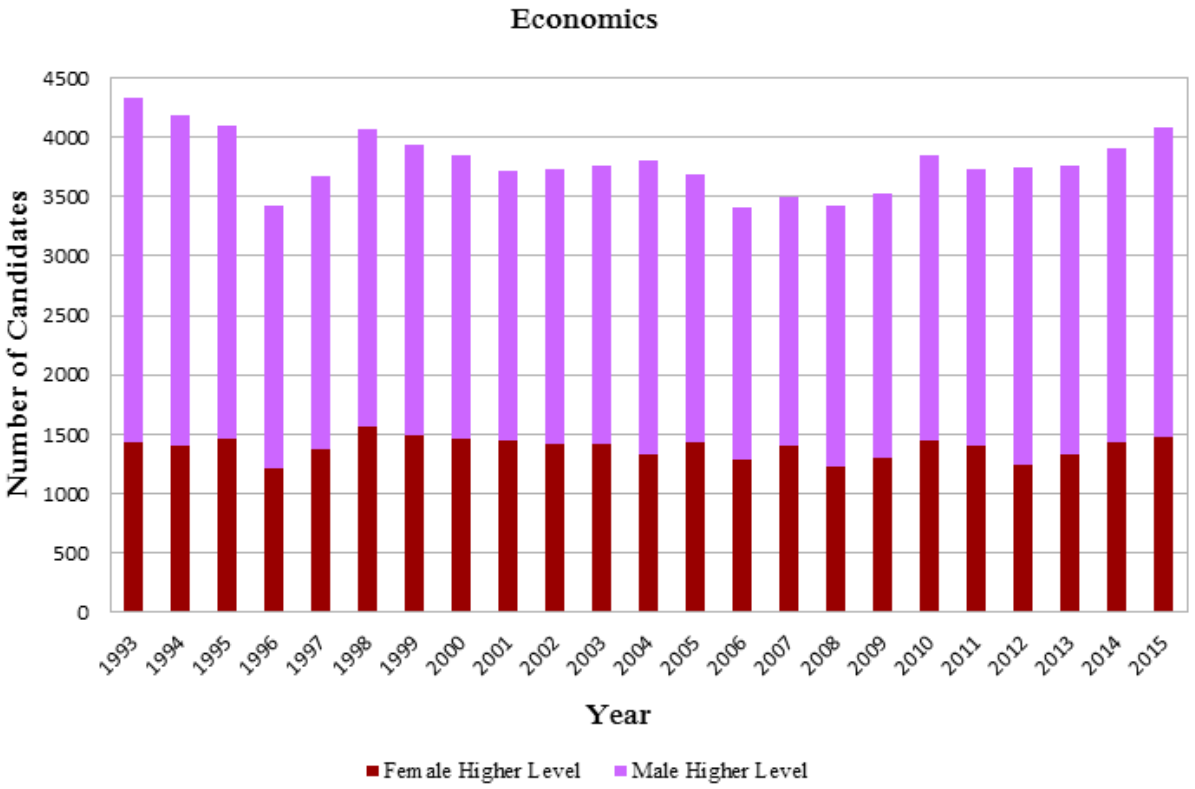

Figure 65 - Economics: Leaving Certificate Female and Male Higher Level

C.4 English

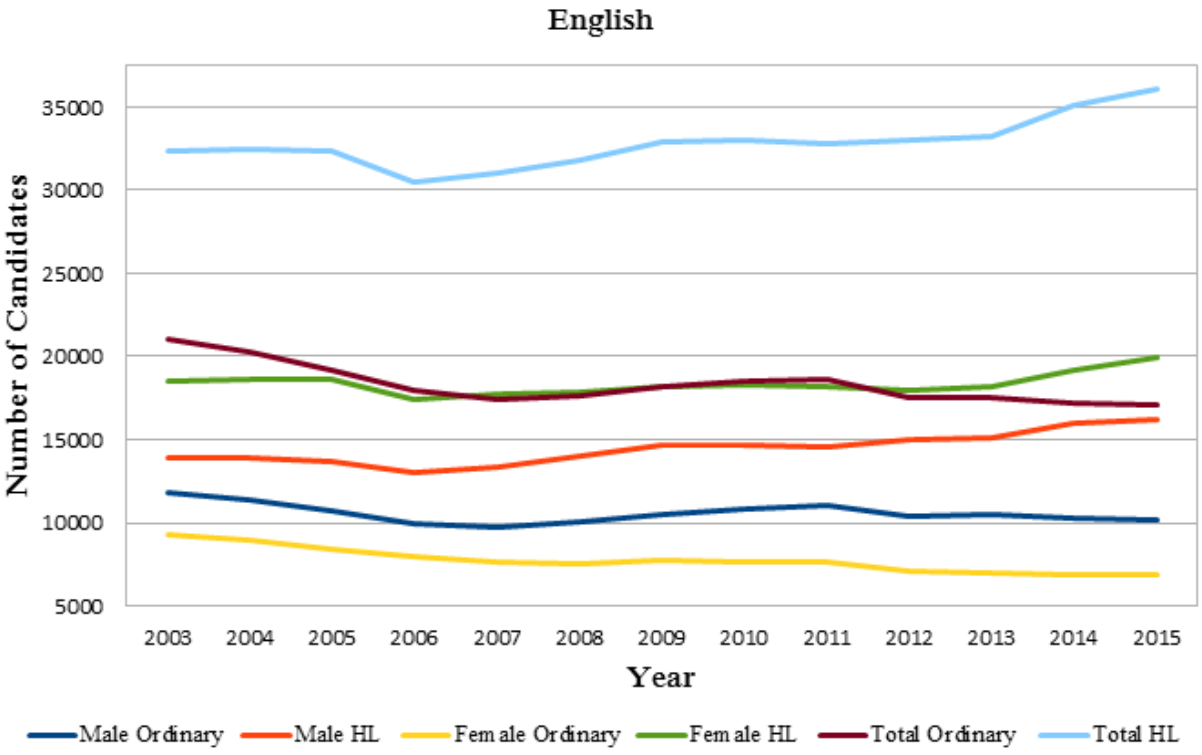

Figure 66 - English: Leaving Certificate overall

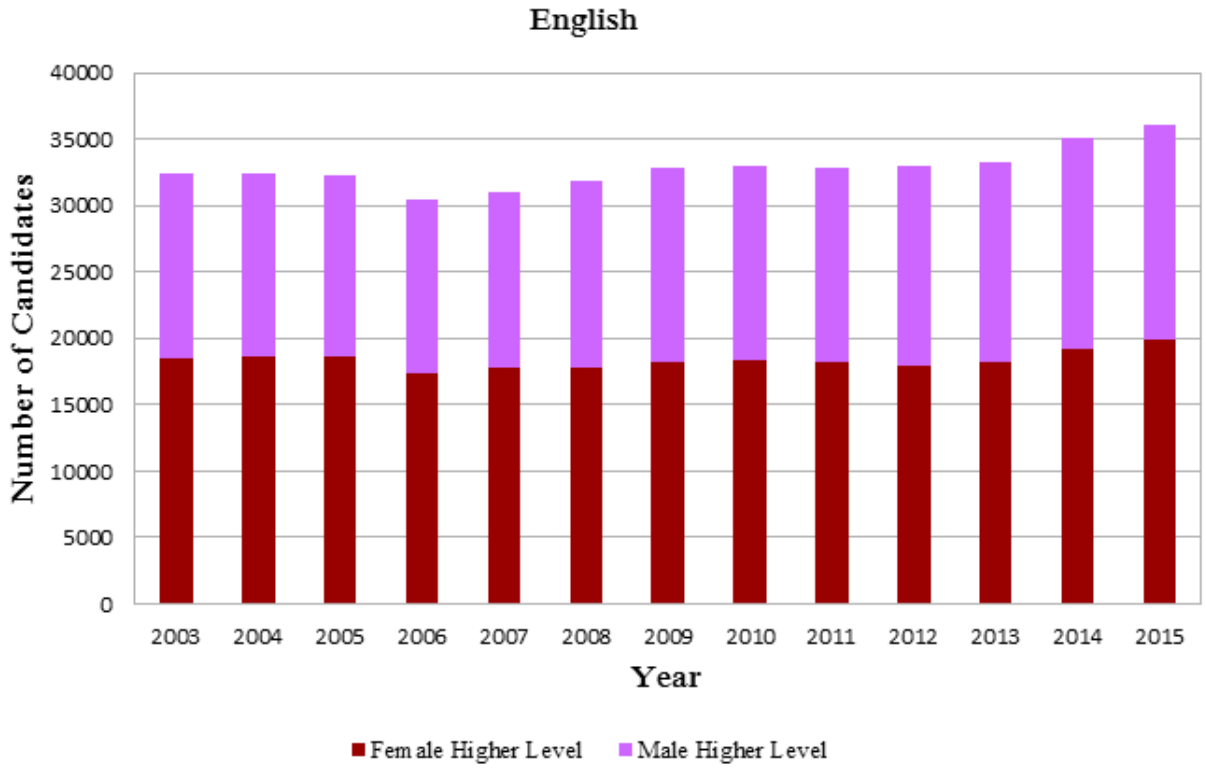

Figure 67 - English: Leaving Certificate Female and Male Higher Level

C.5 French

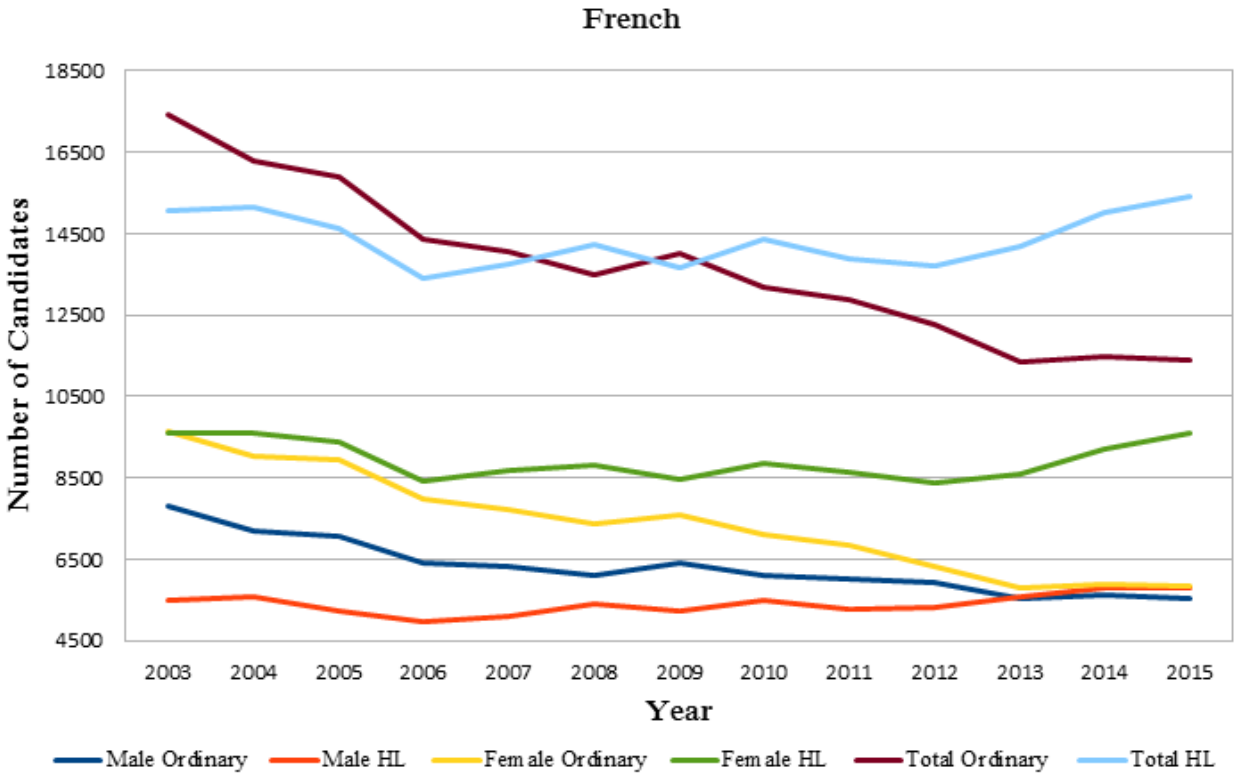

Figure 68 - French: Leaving Certificate overall

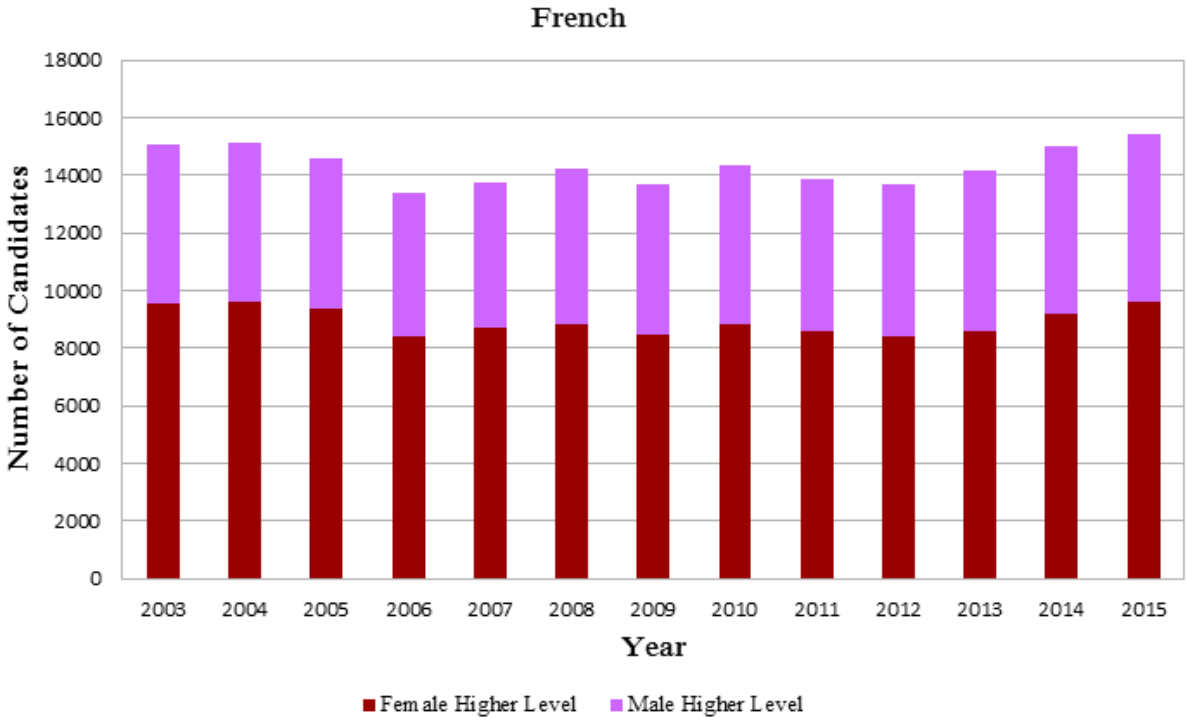

Figure 69 - French: Leaving Certificate Female and Male Higher Level

C.6 Geography

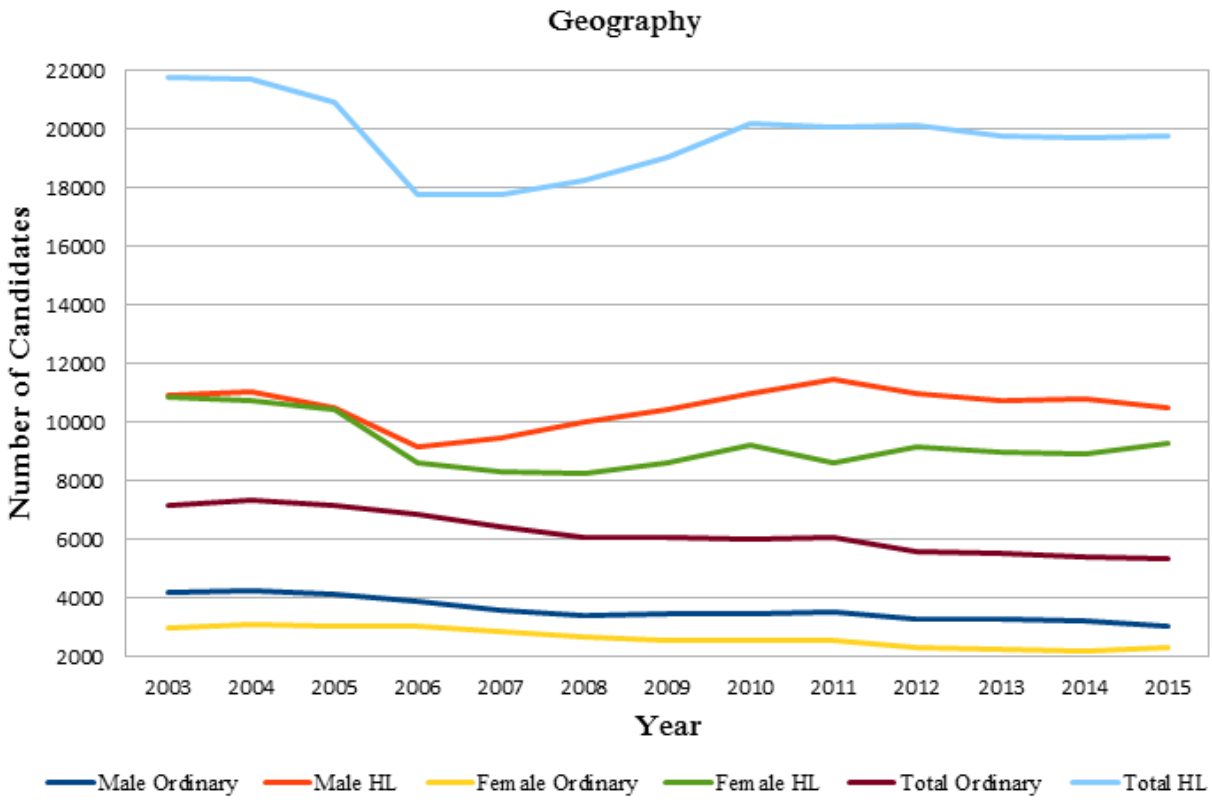

Figure 70 - Geography: Leaving Certificate overall

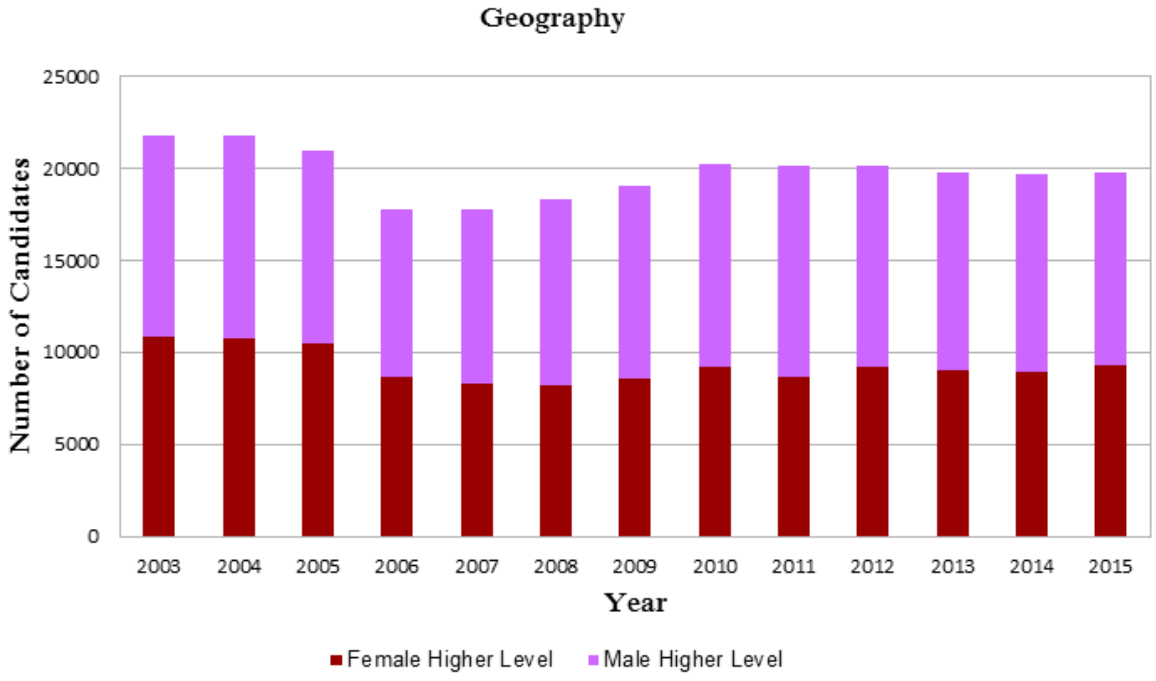

Figure 71 - Geography: Leaving Certificate Female and Male Higher Level

C.7 History

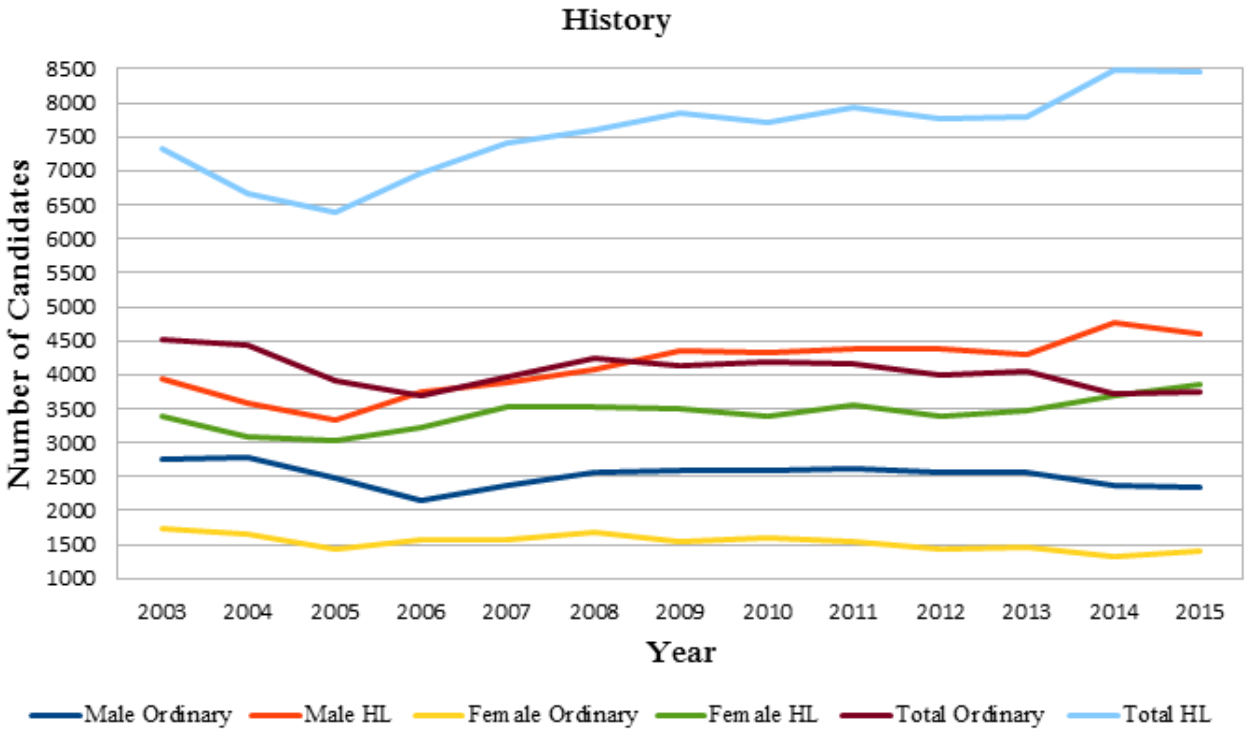

Figure 72 - History: Leaving Certificate overall

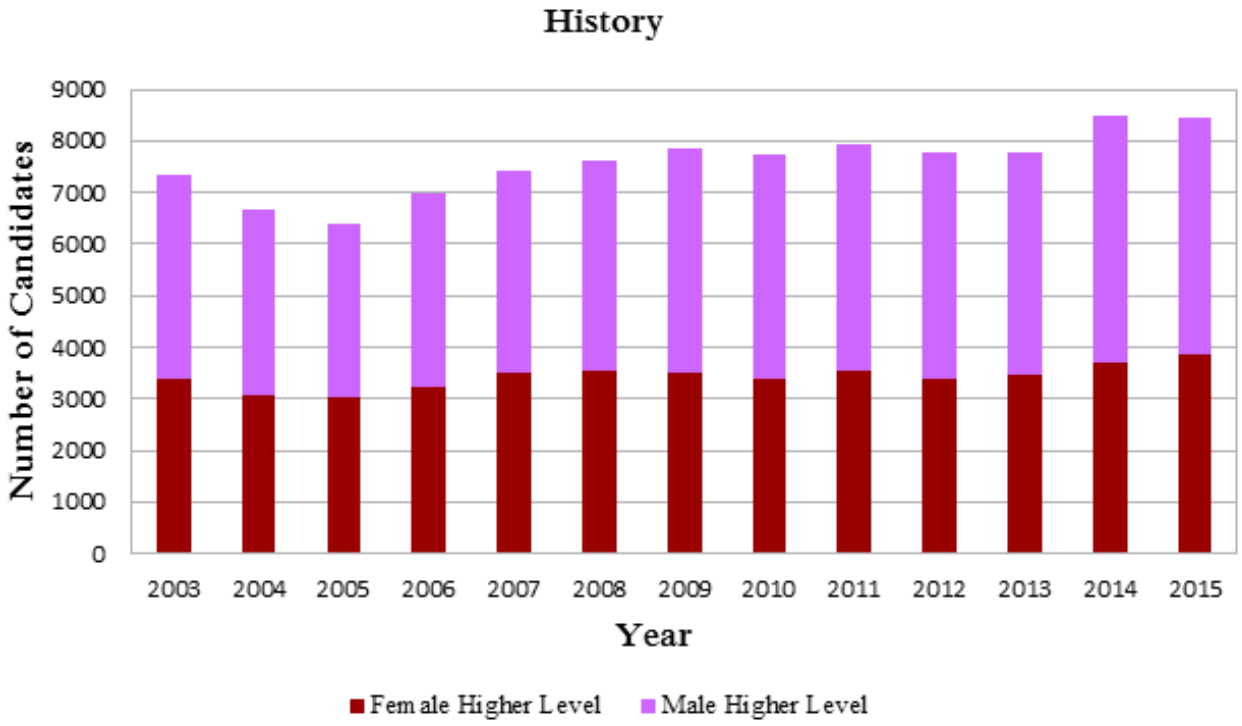

Figure 73 - History: Leaving Certificate Female and Male Higher Level

C.8 Home Economics (S&S)

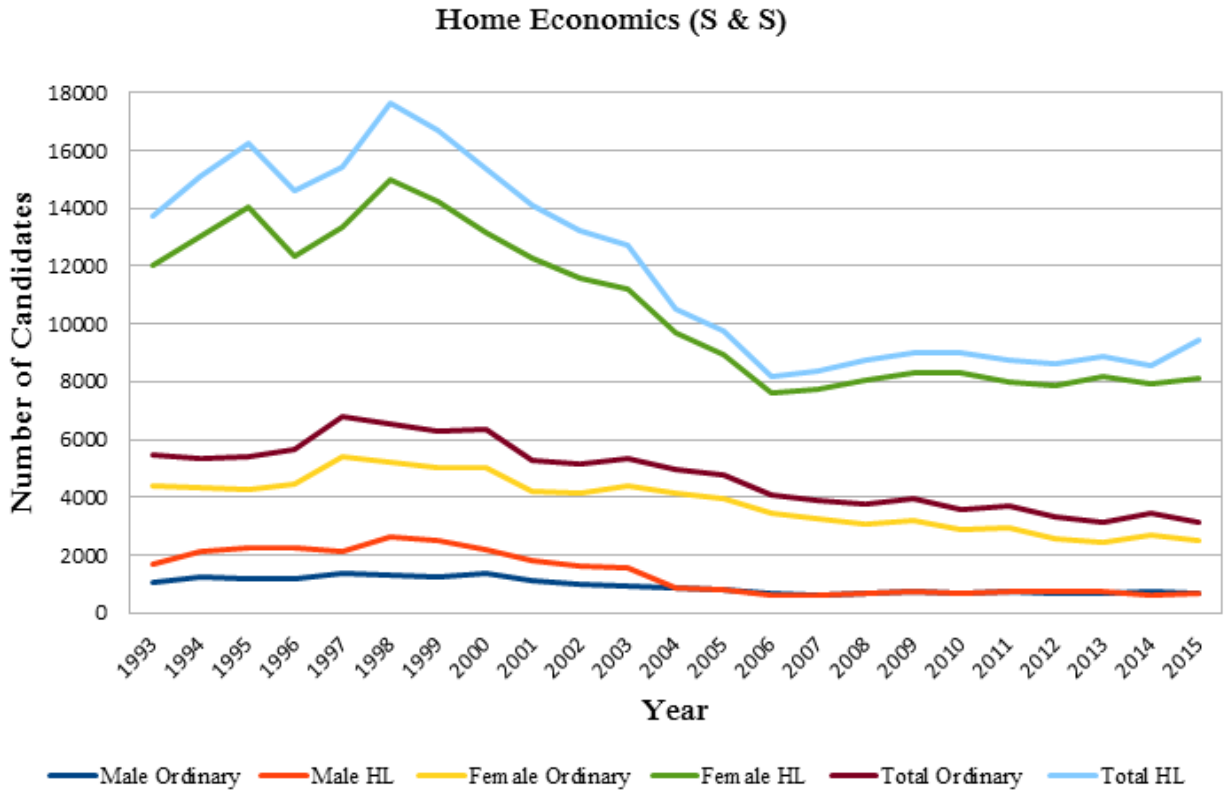

Figure 74 - Home Economics: Leaving Certificate overall

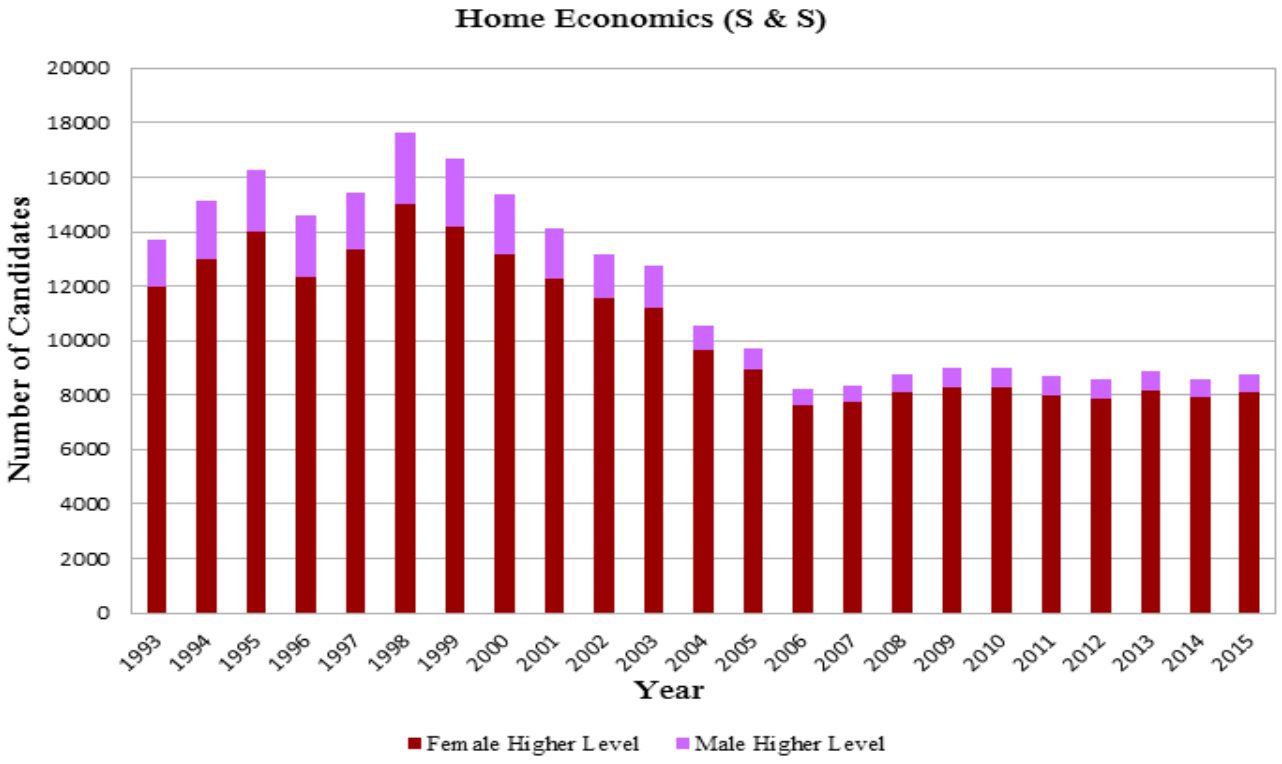

Figure 75 - Home Economics: Leaving Certificate Female and Male Higher Level

C.9 Irish

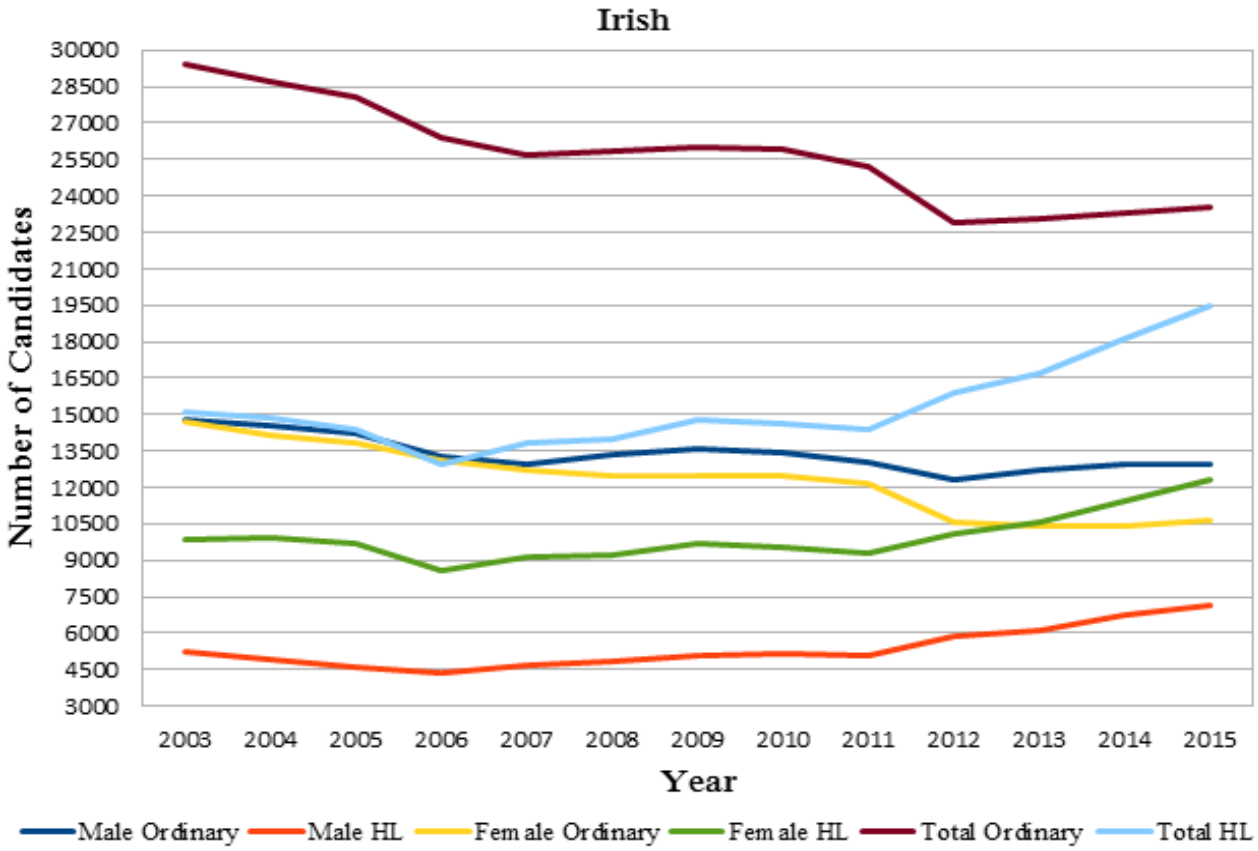

Figure 76 - Irish: Leaving Certificate overall

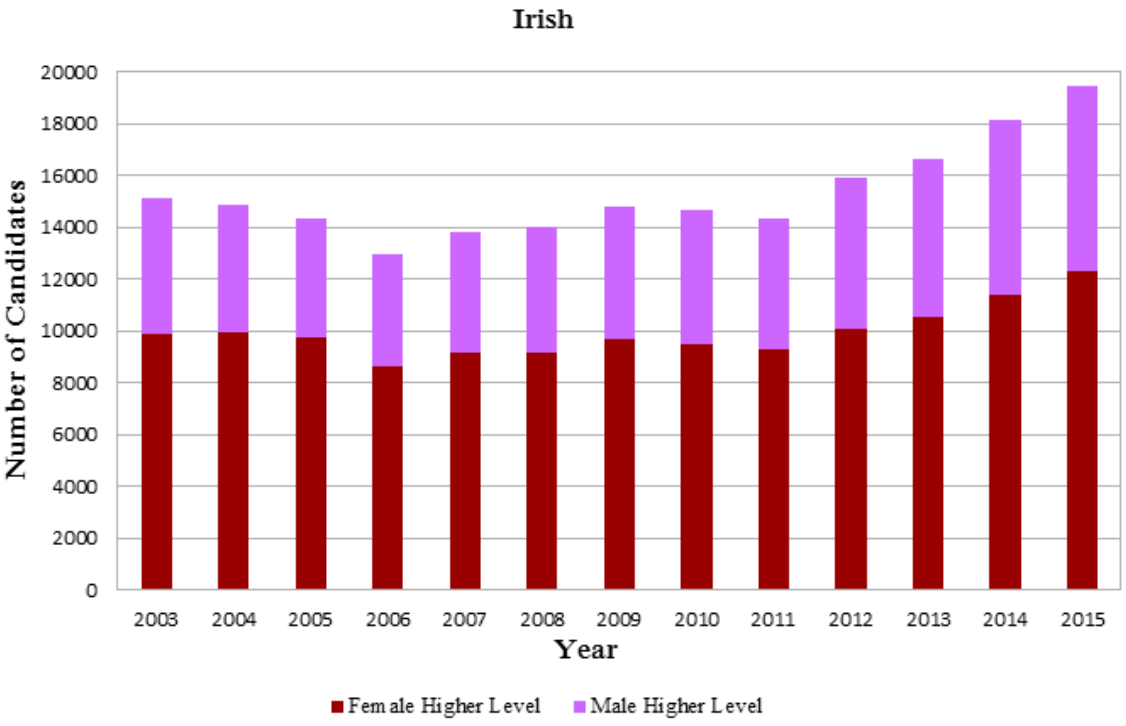

Figure 77 - Irish: Leaving Certificate Female and Male Higher Level