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Is performance in Mathematics and Statistics related to Success in Business Education?

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Abstract

Purpose-The purpose of the article is to gain more insight into factors that can explain students' success in business subjects. The focus is on the connection between performance in introductory courses in business mathematics and business statistics and success in various business subjects.

Design/methodology/approach-Use of a regression model with administrative data from a business school in Norway over a period of 10 years.

Findings- The findings show a strong correlation, especially in quantitative subjects. The results suggest that statistical skills are more strongly related to academic success than mathematical skills.

Research limitation/implications- Data are collected from only from one school. No information on undergraduates' personality and behaviour is available.

Originality/value- There are limited published studies that have explored the relationship between success in statistics and later achievements in business courses. This is useful knowledge for planning the content of the bachelor's programme.

Keywords: business education, performance, regression model, statistical skills, mathematical skills

Introduction

Introductions to business statistics and business mathematics are compulsory courses in many undergraduate programmes for business students. Both subjects are believed to be important instruments and tools for achievement in business subjects. Though there is some overlap between the two, they have different focuses. Mathematics deals with the study of numbers, quantities, and shapes. It includes areas such as algebra, geometry, calculus, and topology. Mathematics can solve problems related to finance, accounting, and economics. The tool can help to calculate costs and find the optimal pricing strategy for a product. Undergraduates who can use mathematical thinking in business problems and perform calculations accurately tend to succeed in business education. There are many published articles that have studied the link between mathematical background and skills and performance in economic and business subjects (Alcock et al., 2008; Arnold & Straten, 2012; Lee & Lee, 2009).

Few studies have investigated the relationship between statistical skills and success in business subjects, even though statistics is a key subject for economics and business students. An exception is the subject of accounting. Statistics focuses on collecting, analysing, and interpreting data. It includes descriptive statistics, probability theory, and inferential statistics. Statistics is helpful to consider risk, test hypotheses, and make predictions. Research shows a strong relationship between mathematical abilities and performance in business statistics (Johnson & Kuennen, 2006; Noser et al., 2008). However, Opstad (2022a) does not find any significant association. Students who have a solid foundation in statistics and can apply statistical concepts to real-world business problems are more likely to succeed in many business courses. Several researchers have analysed the importance of statistics for final grades in accounting-related subjects (Kirk & Spector, 2006; Onay & Benligiray, 2018). On the other hand, many studies have analysed how the GPA (grade point average) from upper secondary school or the first year of an undergraduate programme influences further performance (Bacon & Bean, 2006; Damianov et al., 2009; Jones et al., 2013).

This article stands out from earlier research in that it simultaneously examines how presentations in both statistics and mathematics are linked to further success in the various business subjects.

Good exam grades are related to success in working life (Westerman et al., 2012). Hence, it is useful to know which factors contribute to good performance in business courses.

Mathematical Skills and Hypothesis

Mathematical skills are important for lot of fields within higher education (Joyce et al., 2017). This includes business education (Asian-Chaves et al., 2021). Such basic knowledge is regarded as necessary to achieve high academic performance in business fields, especially in quantitative courses (Opstad,2018). Anderson et al. (1994) reported a positive association between having taken calculus and students' performance in microeconomics. Other researchers have confirmed that mathematical skills are a key predictor for success in an introductory economic class (Ballard & Johnson, 2004; Mallik & Basu, 2009). This explains why studying more mathematics at upper secondary school helps students to increase their performance in economics courses at university level (Asian-Chaves et al., 2022). Alcock et al. (2008) suggested a significant positive relationship between mathematical skills and performance in both micro- and macroeconomics, but with a stronger impact for microeconomics.

In other quantitative courses such as finance, the research shows similar results (Ely & Hittle, 1990; Grover et al., 2009; Ross et al., 2020; Uyar & Güngörmüş, 2011). According to Guidry (2020), students who struggle with mathematics will face substantial challenges managing advanced courses in financial analysis.

The findings around the link between mathematical skills and success in accounting courses are mixed. Guney (2009) and Kealey et al. (2005) reported a positive relationship between mathematical abilities and performance on accounting courses. Other researchers do not find mathematics to have any influence on achievements in accounting (Benligiray & Ahmet, 2017).

Management-oriented subjects differ from quantitative courses. They require a higher degree of verbal and organizational skills (Bartlett et al., 1993; Benligiray & Ahmet, 2017). Hence, mathematical and quantitative abilities are less important for success in such subjects. Even so, Brookshire and Palocsay (2005) found a positive correlation between performance in mathematics and success on management courses. However, there are many indications that the field of business law stands out (Alcock et al., 2008). An explanation may be that a strong mathematical background make students better at handling problem-solving and higher order logic. Hence, they perform better in law studies.

Hypothesis 1(H1): Students' success in business subjects is related to mathematical skills.

Statistical Skills and Hypothesis

Kirk and Spector (2006) suggested a positive link between success in statistics and performance on accounting courses, but they could not detect a similar connection between mathematics and these subjects.

Marcal and Roberts (2001) reported a significant positive relationship between statistical abilities and achievement on finance courses. Brookshire and Palocsay (2005) did not find any significant connection between statistical abilities and achievement on management courses.

Hypothesis 2(H2): Students' success in business subjects is related to statistical skills.

Data and Methods

The analysis is based on administrative data from a business school in Scandinavia over a period of ten years (2010–2019). For compulsory subjects, the number of observations per year is about 200. Some of the subjects are voluntary, or the subject has been offered only in a limited way. This explains why for some of the subjects there are few observations (see Table 1). There are also examples of some subjects with access to data only for a more limited period. In these cases, the number of observations is given in parentheses. In any case, the figures are so large that they provide a good basis for closer analysis. Table 1 presents descriptive statistics of all the variables used in this study.

Table 1. Descriptive statistics

	Mean	SD
Gender (0:F, 1:M)	.49	.50
GPA (grade point average, upper secondary school)	52.9	3.78
Business subjects and final grades[1]		
Organizations and Management (OM) 1st year	3.07	1.07
Business Mathematics (BM) 1st year	3.29	1.30
Business Statistics (BS) 1st year	3.35	1.26
Microeconomics (MIE) 1st year	3.21	1.12
Macroeconomics (MAE) 2nd year	2.91	1.29
Macroeconomics and Finance Market (MAFM) (N=268) 3rd year	3.58	1.09
Applied Microeconomics (AMIE) (N=258)	3.48	1.02
Financial Accounting (FA) 1st year	3.42	1.25
Cost Accounting (CA) 2nd year	3.32	1.42
Financial Statements (FS) (N=191) 3rd year	3.58	1.25
Investment and Financial Analysis (IFA) (N=557) 2nd year	3.32	1.21
Quantitative and Qualitative Methods (QQM)(N=839) 3rd year	3.35	1.26
Marketing Basis Course (MABC) 1st year	2.89	.96
Marketing Communication (MAC) (N=643) 3rd year	3.31	1.01
Ethics and Social Responsibility (ESR)(N=770) 3rd year	3.39	1.03
Business Law (BL) (N=796) 2nd year	3.02	1.02
Business Strategy (BSt) 2nd year	3.02	1.04
Leadership (LS)(N=393) 3rd year	3.32	1.07
Organizational Psychology (OP) (N=635) 3rd year	2.94	.97

Note: [1] Final grades 1: E, 2: D, 3: C, 4: B, 5: A

(F is not included)

In this project, a standard linear regression model is used where the exam grade in the different business subjects is the dependent variable. As explanatory variables, the focus is on performance in the two introductory subjects, business mathematics (BM) and business statistics (BS). The first subject is offered in the first semester (in the autumn) and the next in the second semester (spring), Hence, only subjects taken either in the second semester or later

in the bachelor programme are included in this analysis. In this study, it is assumed that performance in mathematics and statistics is an indicator of skills in these two subjects.

Control Variables

Many studies report that GPA and gender influence students' achievements. There is a significant difference between the GPA from upper secondary school, which is the criterion for accessing the programme, and the GPA the first year after arriving on campus. Published articles suggest that GPA from upper secondary school is positively related to achievements in business studies (Abdullah, 2011; Alhajraf & Alasfour, 2014 Cyrenne & Chan, 2012; Sulphey et al., 2018). Since GPAs determine who gets the entry ticket, it is not surprising that those who have high scores at intake also perform well in various subjects. Especially with cumulative knowledge, the first year GPA is a good predictor for further success. Fundamental understanding is covered in the early part, and students' performance in further courses depends on how they manage the introduction courses (Guidry, 2020). D'Souza and Maheshwari (2011) provide evidence that current GPA scores are positively related to students' performance in management science courses. Borde (2007) suggests that undergraduate GPS is a better indicator of success in a business finance course than GMAT (The Graduate Management Admission Test) scores. Al-Rashed (2001) found GPA to be the strongest factor to predict performance in accounting subjects. Brookshire and Palocsay (2005) came to the same result regarding management courses. First year GPA seems to be a good predictor of further success in business subjects (Opstad, 2022b; Parrish, 2013).

There has been a lot of research on the link between gender and performance in economic and administrative subjects. The research shows mixed and contradictory results. Kim et al. (2022) suggested that men perform better than women, especially in quantitative courses. This is consistent with the finding of Krishna and Orhun (2022). Other studies conclude that female students have higher success than male students (Corpuz et al., 2022; Ezenwafor et al., 2022). There are published papers reporting no or only a minor gender gap (Papageorgiou & Halabi, 2014; Schmidt et al., 2022).

In this study, we use gender, GPA from upper secondary school, and performance in Organizations and Management (OM) as control variables. Organizations and Management is an introductory course (first semester) that provides students with a foundation in the principles and practices of management. This course, taken by students in their first year of business studies, probably has a significant impact on their success in subsequent business courses. It helps students to develop a broad understanding of the various functions of business and the ways in which they are interconnected. OM introduces the undergraduates to concepts such as organizational behaviour, strategy, and leadership. Those components are important for success in other business courses. This is a non-quantitative course. It rewards students who are proficient in verbal presentation.

Results

Business Mathematics

Performance in BM is positively correlated with success in many business subjects, but the results are mixed. The effect is strong for the introduction courses in economics, but the impact is small and not significant for the advanced courses in the same subject, see Table 2. (cf. MAFM (Macroeconomics and Finance Market) and AMIE (Applied Microeconomics)). The

same tendency applies to accounting courses (Table 3). Students' performance in BM is strongly related to the exam grade in accounting courses like FA (Financial Accounting) and CA (Cost Accounting), but not FS(Financial Statements). For the finance subject IFA(Investment and Financial Analysis) and the methodology subject QQM (Quantitative and Qualitative Methods), there is no significant correlation with BM (Table 4). Of the non-quantitative subjects (Tables 5 and 6), a positive significance effect is registered only in relation to the introductory course in marketing (MABC) and law (BL). Hypothesis 1 is partially confirmed.

Table 2. Regression model: economics courses as dependent variables

Variables	Microeconomics (MIE)		Macroeconomics (MAE)		Macroeconomics and Finance Market (MAFM)		Applied Microeconomics (AMIE)	
	B	T-value	B	T-value	B	T-value	B	T-value
Gender	.010	.415	.095	3.51***	.295	3,96***	-.172	-2.61*
GPA	.077	3.10**	.098	3.50***	.025	.33	.018	.28
OM	.176	6.98***	.204	7.28***	.177	2.23*	.178	2.66**
BM	.284	10.13***	.188	6.03***	.068	.83	.088	1.16
BS	.350	12.53***	.275	8.29***	.457	5.53***	.454	6.05***
Adj,R^2	382		.261		.361		.333	
N	1 035		1 003		119		156	

* P<.05, **:P<.01, *** P<.001. Standardized coefficients B. Accepted level of variance inflation factor (VIF).

Table 3. Regression model: accounting courses as dependent variables

Variables	Financial Accounting (FA)		Cost Accounting (CA)		Financial Statements (FS)	
	B	T-value	B	T-value	B	T-value
Gender	-.042	-1.55	.056	1.86	-.074	-.63
GPA	.108	3.88***	.078	2.57*	-.060	-.50
OM	.184	6.47***	.139	4.43***	.268	2.18*
BM	.206	6.45***	.200	5.72***	.156	1.20
BS	.281	8.85***	.314	8.92***	.357	2.63*
Adj,R^s	.268		.262		.266	
N	973		814		55	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Business Statistics
BS is significantly positively correlated with the business courses included in this analysis. The impact is particularly strong for finance (Table 4) and advanced courses in economics (Table 2) but also notable for the non-quantitative subjects except for Leadership (Table 5 and 6). Hypothesis 2 is confirmed.

Table 4. Regression model: finance and methods courses as dependent variables

	Investment and Financial Analysis (IFA)		Quantitative and Qualitative Methods (QQM)	
Variables	B	T-value	B	T-value
Gender	.161	2.57*	-.074	-1.34
GPA	-.026	-.40	.006	.10
OM	.149	2.28*	.181	3.12**
BM	.133	1.82	.043	.67
BS	.412	5.59***	.302	4.59***
Adj,R^s	.277		.162	
N	175		274	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Table 5. Regression model: mixed non-quantitative courses as dependent variables

Variables	Marketing Basis Course (MABC)		Marketing Communication (MAC)		Ethics and Social Responsibility (ESR)		Business Law (BL)	
	B	T-value	B	T-value	B	T-value	B	T-value
Gender	-.066	-2.40*	-.210	-3.29**	-.158	-2.82*	-.148	-2.55*
GPA	.053	1.90	.053	.83	.042	.73	.100	1.72
OM	.383	13.45***	.264	3.98***	.123	2.09*	.147	2.47*
BM	.129	4.08***	.003	.04	.075	1.14	.157	2.37*
BS	.105	3.31***	.194	2.66**	.212	3.18**	.213	3.17**
Adj,R^s	.233		.163		.115		.176	
N	1 011		211		282		250	

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

Table 6. Regression model: management courses as dependent variables.

Variables	Business Strategy (BSt)		Leadership (LS)		Organizational Psychology (OP)	
	B	T-value	B	T-value	B	T-value
Gender	-.078	-2.52*	.111	1.01	-.181	-2.80**
GPA	-.084	-2.68**	-.025	-.22	.155	2.38*
OM	.265	8.26***	.258	2.21*	.201	3.00**
BM	.033	.92	.105	.87	.014	.185
BS	.216	5.91***	-.094	-.76	.198	2.63**
Adj,R^s	.152		.021		.158	
N	881		84		204	

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

The Control Variables

Achievement in the introductory course in management (OM) is significantly positively correlated with exam grades for all business subjects in this study. The impact is strong for both the quantitative and the non-quantitative courses.

When it comes to GPA from upper secondary school, the results are mixed. There is a positive significant relationship to success in only five of the subjects, The impact is most marked for the introductory courses. For BSt, the impact is negative. For most of the subjects (9 out of 16), GPA has no significant effect.

For some of the subjects, there are significant outcomes regarding gender. The following subjects favour men: MAE, MAFM, IFA. They are all quantitatively oriented courses. In the subjects AMIE, MABC, MAC, ESR, BL, BSt and OP, the women come out on top.

The regression models have an acceptable level of adjusted R^2, the models explaining between 10 and 30 per cent of variability in the dependent variables with exception of LS.

Discussion

Statistics and Mathematics

This study confirms previous research finding that students who perform well in their first year of higher education are more likely to continue to do well in subsequent years (Crowther & Briant, 2021). In this investigation, only a selection of subjects from the first year is included. The focus is on the connection between achievements in mathematics and statistics and undergraduates' further success in business education.

Business mathematics is essential for success in many business courses. Despite this, some authors report a decline in mathematical and statistical knowledge when students enter universities (Silva et al., 2016). These skills are important tools in economics and finance subjects. Additionally, calculation is a necessity in accounting subjects. Students who can apply mathematical concepts to business problems and perform calculations accurately are more likely to succeed in these courses. This relationship is well documented in the literature (Lee & Lee, 2009). This analysis gives a more mixed result. There is a strong correlation between performance in mathematics and the exam grade in the introductory courses in economics, accounting, and marketing. Not surprisingly, there is a strong impact in microeconomics, since the presentation in this subject is largely a mathematical presentation. Students who do not master mathematics may have difficulty keeping up. The effect on the subject of law is in line with previous findings (Alcock et al., 2008). In principle, BL may require skills other than mathematics. The main reason why one can still demonstrate a correlation between mathematical abilities and performance in law subject may be that those who are proficient in mathematics use analytical or logical reasoning, focus on problem-solving, are more solution-oriented and pay attention to important details. These are skills that can contribute to success in BL.

Business students belong to a heterogeneous group with great variation in the composition of subjects. Some business students focus on fields other than quantitative subjects. Many non-quantitative subjects favour skills other than mathematical ones. This explains why business students who do not master mathematics well tend to choose non-quantitative majors (Opstad, 2019).

Perhaps somewhat surprisingly, this study shows no statistical correlation between performance in BM and the exam grade in advanced courses in economics, finance, accounting, and marketing (see MAFM, AMIE, FS, IFA and MAC, Tables 2–4). The picture is completely different in terms of skills in statistics. There is a strong positive correlation between performance in BS and success in business subjects. The effects tend to be greater for supplementary subjects than for the introductory subjects (with the exception of management courses). For macroeconomics, the value of the coefficient B is .467 in MAFM versus .275 in

MAE (see Table 2). The same tendency is recorded for microeconomics, accounting, and marketing (see Tables 2–5). There are few studies that have looked directly at the connection between statistical skills and success in the various business subjects. However, the findings of this analysis confirm the assumption of Kirk and Spector (2006) that statistical skills are more linked to performance for business students than mathematical abilities. However, Kirk and Spector (2006) limited themselves to the analysis only of accounting subjects. Though there are few published articles that specifically address the correlation between business statistics and students' success in business subjects, there are papers that provide some valuable insights into the function of statistics in business education. According to Garfield and Ben-Zvi (2007), statistical knowledge improves ability in higher order thinking and reasoning and is essential for interpreting the use of empirical data. Undergraduates with strong statistical skills will probably tend to do better in understanding, interpreting, and analysing data. This can be a crucial factor for strategic decisions in various business disciplines. Furthermore, these students will improve their abilities to solve complex problems, evaluate investment opportunities, or assess risks. These are critical factors in some business domains—for instance, within finance and economics. The students will be more skilled in critical thinking, forecasting and predictive modelling. Strong statistical skills help the undergraduate to improve communications using statistical data. This will improve strategic planning. All of this may help explain the close connection between statistical ability and success in the various areas of business school. This knowledge is perhaps even more important in the advanced courses. That may be the reason for the results in this analysis.

The Control Variables

There is a strong correlation between OM and further success. Undergraduates with a solid understanding of organizational behaviour may be better equipped to work effectively and communicate with others, which may be important in courses such as marketing, finance, and management. Besides, a good understanding of strategy may help students to analyse business problems and make informed decisions, which is important in many business courses. OM can also help students develop important skills such as critical thinking, problem solving, and communication. These skills are essential for success on business courses (D'Souza & Maheshwari, 2010).

Upper secondary school academic performance is important as an entrance ticket to higher education but is only to a limited extent connected to success in business education. There may be several reasons for this. Business studies favour specific skills, while upper secondary school focuses on a broad range of subjects. Additionally, there are significant differences in grading at different high schools in Norway. There is widespread use of additional points for age, military staff and more. Another important factor is that students have become more mature and changed their study habits. This may explain why the relationship between high school GPA and success decreases with the length of study in this research.

There is a lot of literature on gender and performance in business disciplines. There are some indications that traditional gender differences have narrowed (Ramirez & Lofgren, 2023). It is interesting to note that in this study there are several subjects where women do better than men rather than the other way around.

Conclusions and Further Research

This paper analyses the link between students' achievements in the two subjects mathematics and statistics and further success in business education. Similar to previous research, this study

finds a strong link between mathematical skills and academic success, especially in introductory courses. At the bachelor level, relatively simple mathematics is applied, but it is an important instrument for good logical and analytical presentation This applies especially to quantitative subjects, but the impact is also significant for law. The link to success is much stronger for statistical skills than for mathematical ones, and impacts are greater for the advanced courses.

Mathematics and statistical skills seem to be predictors of success in business education. Business statistics provides students with a solid understanding of quantitative analysis, which is essential for understanding many business concepts. This understanding can help students to think critically and to approach complex business problems with more confidence. Business statistics are likely to have a solid foundation in the key skills that are essential for success in many business fields. This may explain why the relationship with statistical skills increases throughout business education.

It is desirable to have more studies that analyse this and that also include master students. It is interesting to see if other studies can confirm the results in this analysis.

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Is performance in Mathematics and Statistics related to Success in Business Education?

Abstract

Purpose-The purpose of the article is to gain more insight into factors that can explain students' success in business subjects. The focus is on the connection between performance in introductory courses in business mathematics and business statistics and success in various business subjects.
Design/methodology/approach-Use of a regression model with administrative data from a business school in Norway over a period of 10 years.
Findings- The findings show a strong correlation, especially in quantitative subjects. The results suggest that statistical skills are more strongly related to academic success than mathematical skills.
Research limitation/implications- Data are collected from only from one school. No information on undergraduates' personality and behaviour is available.
Originality/value- There are limited published studies that have explored the relationship between success in statistics and later achievements in business courses. This is useful knowledge for planning the content of the bachelor's programme.
Keywords: business education, performance, regression model, statistical skills, mathematical skills

Introduction

Introductions to business statistics and business mathematics are compulsory courses in many undergraduate programmes for business students. Both subjects are believed to be important instruments and tools for achievement in business subjects. Though there is some overlap between the two, they have different focuses. Mathematics deals with the study of numbers, quantities, and shapes. It includes areas such as algebra, geometry, calculus, and topology. Mathematics can solve problems related to finance, accounting, and economics. The tool can help to calculate costs and find the optimal pricing strategy for a product. Undergraduates who can use mathematical thinking in business problems and perform calculations accurately tend to succeed in business education. There are many published articles that have studied the link between mathematical background and skills and performance in economic and business subjects (Alcock et al., 2008; Arnold & Straten, 2012; Lee & Lee, 2009).

Few studies have investigated the relationship between statistical skills and success in business subjects, even though statistics is a key subject for economics and business students. An exception is the subject of accounting. Statistics focuses on collecting, analysing, and interpreting data. It includes descriptive statistics, probability theory, and inferential statistics. Statistics is helpful to consider risk, test hypotheses, and make predictions. Research shows a strong relationship between mathematical abilities and performance in business statistics (Johnson & Kuennen, 2006; Noser et al., 2008). However, Opstad (2022a) does not find any significant association. Students who have a solid foundation in statistics and can apply statistical concepts to real-world business problems are more likely to succeed in many business courses. Several researchers have analysed the importance of statistics for final grades in accounting-related subjects (Kirk & Spector, 2006; Onay & Benligiray, 2018). On the other hand, many studies have analysed how the GPA (grade point average) from upper secondary school or the first year of an undergraduate programme influences further performance (Bacon & Bean, 2006; Damianov et al., 2009; Jones et al., 2013).

This article stands out from earlier research in that it simultaneously examines how presentations in both statistics and mathematics are linked to further success in the various business subjects. As an indicator of success in business education, this study uses the grades achieved in exams for the various subjects. Several authors emphasize that the teaching method and attitudes towards the subject are of great importance in determining whether students succeed (Sharma & Srivastav, 2021). This topic is not discussed in this article.

Good exam grades are related to success in working life (Westerman et al., 2012). Hence, it is useful to know which factors contribute to good performance in business courses.

Mathematical Skills and Hypothesis

Mathematical skills are important for lot of fields within higher education (Joyce et al., 2017). This includes business education (Asian-Chaves et al., 2021). Mathematics knowledge enables students to structure and analyse relationships. Such skills make one a more proficient business economist. Based on economic theory, one can expect a positive connection between mathematical skills and performance in business subjects. There are many published articles that confirm such a relationship.

~~Such B~~basic knowledge is regarded as necessary to achieve high academic performance in business fields, especially in quantitative courses (Opstad,2018). Anderson et al. (1994) reported a positive association between having taken calculus and students' performance in microeconomics. Other researchers have confirmed that mathematical skills are a key predictor for success in an introductory economic class (Ballard & Johnson, 2004; Mallik & Basu, 2009). This explains why studying more mathematics at upper secondary school helps students to increase their performance in economics courses at university level (Asian-Chaves et al., 2022). Alcock et al. (2008) suggested a significant positive relationship between mathematical skills and performance in both micro- and macroeconomics, but with a stronger impact for microeconomics.

In other quantitative courses such as finance, the research shows similar results (Ely & Hittle, 1990; Grover et al., 2009; Ross et al., 2020; Uyar & Güngörmüş, 2011). According to Guidry (2020), students who struggle with mathematics will face substantial challenges managing advanced courses in financial analysis.

The findings around the link between mathematical skills and success in accounting courses are mixed. Guney (2009) and Kealey et al. (2005) reported a positive relationship between mathematical abilities and performance on accounting courses. Other researchers do not find mathematics to have any influence on achievements in accounting (Benligiray & Ahmet, 2017).

Management-oriented subjects differ from quantitative courses. They require a higher degree of verbal and organizational skills (Bartlett et al., 1993; Benligiray & Ahmet, 2017). Hence, mathematical and quantitative abilities are less important for success in such subjects. Even so, Brookshire and Palocsay (2005) found a positive correlation between performance in mathematics and success on management courses. However, there are many indications that the field of business law stands out (Alcock et al., 2008). An explanation may be that a strong mathematical background make students better at handling problem-solving and higher order logic. Hence, they perform better in law studies.

Hypothesis 1(H1): Students' success in business subjects is related to mathematical skills.

Statistical Skills and Hypothesis

in the various business disciplines, students learn to analyse uncertainties and process available data. Being able to do this systematically and strategically is crucial for success in the workplace. An introductory course in statistics is a key factor in developing analytical skills and applying numerical data to conduct meaningful analyses (Hsu et al., 2021). Therefore, Hoerl and Snee (2020) emphasise that if students receive training in statistical thinking, they will become more proficient business economists. Statistical knowledge equips students with the tools they need to interpret, analyse, and effectively use data in various business contexts.

Statistical knowledge can provide a better theoretical foundation for achieving good performance in various subjects at business schools, from quantitative subjects like finance, to more qualitative courses like marketing and organisational theory. In the business world, decision-making is often based on data and analysis. Statistical knowledge enables students to evaluate risk, make forecasts, and identify opportunities In marketing, understanding consumer behaviour and market analysis are essential. Statistical tools such can be applied to optimise marketing strategies. In finance, statistics are vital for risk management, and portfolio optimization. Students can use statistics to evaluate securities, calculate risk and return, and make informed investment decisions.

Kirk and Spector (2006) suggested a positive link between success in statistics and performance on accounting courses, but they could not detect a similar connection between mathematics and these subjects.

Marcal and Roberts (2001) reported a significant positive relationship between statistical abilities and achievement on finance courses. Brookshire and Palocsay (2005) did not find any significant connection between statistical abilities and achievement on management courses.

Hypothesis 2(H2): Students' success in business subjects is related to statistical skills.

Data and Methods

The analysis is based on administrative data from a business school in Scandinavia over a period of ten years (2010–2019). For compulsory subjects, the number of observations per year is about 200. Some of the subjects are voluntary, or the subject has been offered only in a limited way. This explains why for some of the subjects there are few observations (see Table 1). There are also examples of some subjects with access to data only for a more limited period. In these cases, the number of observations is given in parentheses. In any case, the figures are so large that they provide a good basis for closer analysis. Table 1 presents descriptive statistics of all the variables used in this study.

Table 1. Descriptive statistics

	Mean	SD
Gender (0:F, 1:M)	.49	.50
GPA (grade point average, upper secondary school)	52.9	3.78
Business subjects and final grades[1]		
Organizations and Management (OM) 1st year	3.07	1.07
Business Mathematics (BM) 1st year	3.29	1.30
Business Statistics (BS) 1st year	3.35	1.26
Microeconomics (MIE) 1st year	3.21	1.12
Macroeconomics (MAE) 2nd year	2.91	1.29
Macroeconomics and Finance Market (MAFM) (N=268) 3rd year	3.58	1.09
Applied Microeconomics (AMIE) (N=258)	3.48	1.02

Financial Accounting (FA) 1st year	3.42	1.25
Cost Accounting (CA) 2nd year	3.32	1.42
Financial Statements (FS) (N=191) 3rd year	3.58	1.25
Investment and Financial Analysis (IFA) (N=557) 2nd year	3.32	1.21
Quantitative and Qualitative Methods (QQM)(N=839) 3rd year	3.35	1.26
Marketing Basis Course (MABC) 1st year	2.89	.96
Marketing Communication (MAC) (N=643) 3rd year	3.31	1.01
Ethics and Social Responsibility (ESR)(N=770) 3rd year	3.39	1.03
Business Law (BL) (N=796) 2nd year	3.02	1.02
Business Strategy (BSt) 2nd year	3.02	1.04
Leadership (LS)(N=393) 3rd year	3.32	1.07
Organizational Psychology (OP) (N=635) 3rd year	2.94	.97

Note: [1] Final grades 1: E, 2: D, 3: C, 4: B, 5: A
(F is not included)

In this project, a standard linear regression model is used where the exam grade in the different business subjects is the dependent variable. As explanatory variables, the focus is on performance in the two introductory subjects, business mathematics (BM) and business statistics (BS). The first subject is offered in the first semester (in the autumn) and the next in the second semester (spring), Hence, only subjects taken either in the second semester or later in the bachelor programme are included in this analysis. In this study, it is assumed that performance in mathematics and statistics is an indicator of skills in these two subjects.

Control Variables
Many studies report that GPA and gender influence students' achievements. There is a significant difference between the GPA from upper secondary school, which is the criterion for accessing the programme, and the GPA the first year after arriving on campus. Published articles suggest that GPA from upper secondary school is positively related to achievements in business studies (Abdullah, 2011; Alhajraf & Alasfour, 2014 Cyrenne & Chan, 2012; Sulphey et al., 2018). Since GPAs determine who gets the entry ticket, it is not surprising that those who have high scores at intake also perform well in various subjects. Especially with cumulative knowledge, the first year GPA is a good predictor for further success. Fundamental understanding is covered in the early part, and students' performance in further courses depends on how they manage the introduction courses (Guidry, 2020). D'Souza and Maheshwari (2011) provide evidence that current GPA scores are positively related to students' performance in management science courses. Borde (2007) suggests that undergraduate GPS is a better indicator of success in a business finance course than GMAT (The Graduate Management Admission Test) scores. Al-Rashed (2001) found GPA to be the strongest factor to predict performance in accounting subjects. Brookshire and Palocsay (2005) came to the same result regarding management courses. First year GPA seems to be a good predictor of further success in business subjects (Opstad, 2022b; Parrish, 2013).

There has been a lot of research on the link between gender and performance in economic and administrative subjects. The research shows mixed and contradictory results. Kim et al. (2022) suggested that men perform better than women, especially in quantitative courses. This is consistent with the finding of Krishna and Orhun (2022). Other studies

conclude that female students have higher success than male students (Corpuz et al., 2022; Ezenwafor et al., 2022). There are published papers reporting no or only a minor gender gap (Papageorgiou & Halabi, 2014; Schmidt et al., 2022).

In this study, we use gender, GPA from upper secondary school, and performance in Organizations and Management (OM) as control variables. Organizations and Management is an introductory course (first semester) that provides students with a foundation in the principles and practices of management. This course, taken by students in their first year of business studies, probably has a significant impact on their success in subsequent business courses. It helps students to develop a broad understanding of the various functions of business and the ways in which they are interconnected. OM introduces the undergraduates to concepts such as organizational behaviour, strategy, and leadership. Those components are important for success in other business courses. This is a non-quantitative course. It rewards students who are proficient in verbal presentation.

There is intense competition for admission to the business school referenced in this study. The age difference is minimal, with most students being just over 20 years old. No data is available regarding whether the students have prior work experience, have undertaken other education, or have completed military service before enrolling in this programme.

Results

Business Mathematics

Performance in BM is positively correlated with success in many business subjects, but the results are mixed. The effect is strong for the introduction courses in economics, but the impact is small and not significant for the advanced courses in the same subject, see Table 2. (cf. MAFM (Macroeconomics and Finance Market) and AMIE (Applied Microeconomics)). The same tendency applies to accounting courses (Table 3). Students' performance in BM is strongly related to the exam grade in accounting courses like FA (Financial Accounting) and CA (Cost Accounting), but not FS(Financial Statements). For the finance subject IFA(Investment and Financial Analysis) and the methodology subject QQM (Quantitative and Qualitative Methods), there is no significant correlation with BM (Table 4). Of the non-quantitative subjects (Tables 5 and 6), a positive significance effect is registered only in relation to the introductory course in marketing (MABC) and law (BL). Hypothesis 1 is partially confirmed.

Table 2. Regression model: economics courses as dependent variables

Variables	Microeconomics (MIE) B	T-value	Macroeconomics (MAE) B	T-value	Macroeconomics and Finance Market (MAFM) B	T-value	Applied Microeconomics (AMIE) B	T-value
Gender	.010	.415	.095	3.51***	.295	3,96***	-.172	-2.61*
GPA	.077	3.10**	.098	3.50***	.025	.33	.018	.28
OM	.176	6.98***	.204	7.28***	.177	2.23*	.178	2.66**
BM	.284	10.13***	.188	6.03***	.068	.83	.088	1.16
BS	.350	12.53***	.275	8.29***	.457	5.53***	.454	6.05***
Adj,R^2	382		.261		.361		.333	
N	1 035		1 003		119		156	

* P<.05, **:P<.01, *** P<.001. Standardized coefficients B. Accepted level of variance inflation factor (VIF).

Table 3. Regression model: accounting courses as dependent variables

Variables	Financial Accounting (FA)		Cost Accounting (CA)		Financial Statements (FS)	
	B	T-value	B	T-value	B	T-value
Gender	-.042	-1.55	.056	1.86	-.074	-.63
GPA	.108	3.88***	.078	2.57*	-.060	-.50
OM	.184	6.47***	.139	4.43***	.268	2.18*
BM	.206	6.45***	.200	5.72***	.156	1.20
BS	.281	8.85***	.314	8.92***	.357	2.63*
Adj,R^s	.268		.262		.266	
N	973		814		55	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Business Statistics

BS is significantly positively correlated with the business courses included in this analysis. The impact is particularly strong for finance (Table 4) and advanced courses in economics (Table 2) but also notable for the non-quantitative subjects except for Leadership (Table 5 and 6). Hypothesis 2 is confirmed.

Table 4. Regression model: finance and methods courses as dependent variables

Variables	Investment and Financial Analysis (IFA)		Quantitative and Qualitative Methods (QQM)	
	B	T-value	B	T-value
Gender	.161	2.57*	-.074	-1.34
GPA	-.026	-.40	.006	.10
OM	.149	2.28*	.181	3.12**
BM	.133	1.82	.043	.67
BS	.412	5.59***	.302	4.59***
Adj,R^s	.277		.162	
N	175		274	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Table 5. Regression model: mixed non-quantitative courses as dependent variables

Variables	Marketing Basis Course (MABC)		Marketing Communication (MAC)		Ethics and Social Responsibility (ESR)		Business Law (BL)	
	B	T-value	B	T-value	B	T-value	B	T-value
Gender	-.066	-2.40*	-.210	-3.29**	-.158	-2.82*	-.148	-2.55*
GPA	.053	1.90	.053	.83	.042	.73	.100	1.72

OM	.383	13.45***	.264	3.98***	.123	2.09*	.147	2.47*
BM	.129	4.08***	.003	.04	.075	1.14	.157	2.37*
BS	.105	3.31***	.194	2.66**	.212	3.18**	.213	3.17**
Adj,R^s	.233		.163		.115		.176	
N	1 011		211		282		250	

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

Table 6. Regression model: management courses as dependent variables.

	Business Strategy (BSt)		Leadership (LS)		Organizational Psychology (OP)	
Variables	B	T-value	B	T-value	B	T-value
Gender	-.078	-2.52*	.111	1.01	-.181	-2.80**
GPA	-.084	-2.68**	-.025	-.22	.155	2.38*
OM	.265	8.26***	.258	2.21*	.201	3.00**
BM	.033	.92	.105	.87	.014	.185
BS	.216	5.91***	-.094	-.76	.198	2.63**
Adj,R^s	.152		.021		.158	
N	881		84		204	

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

The Control Variables

Achievement in the introductory course in management (OM) is significantly positively correlated with exam grades for all business subjects in this study. The impact is strong for both the quantitative and the non-quantitative courses.

When it comes to GPA from upper secondary school, the results are mixed. There is a positive significant relationship to success in only five of the subjects, The impact is most marked for the introductory courses. For BSt, the impact is negative. For most of the subjects (9 out of 16), GPA has no significant effect.

For some of the subjects, there are significant outcomes regarding gender. The following subjects favour men: MAE, MAFM, IFA. They are all quantitatively oriented courses. In the subjects AMIE, MABC, MAC, ESR, BL, BSt and OP, the women come out on top.

The regression models have an acceptable level of adjusted R^2, the models explaining between 10 and 30 per cent of variability in the dependent variables with exception of LS.

Discussion

Statistics and Mathematics

This study confirms previous research finding that students who perform well in their first year of higher education are more likely to continue to do well in subsequent years (Crowther & Briant, 2021). In this investigation, only a selection of subjects from the first year is included. The focus is on the connection between achievements in mathematics and statistics and undergraduates' further success in business education. This analysis confirms and documents that it is highly sensible to have mandatory introductory courses in mathematics and statistics at the bachelor's level for business students.

Business mathematics is essential for success in many business courses. Despite this, some authors report a decline in mathematical and statistical knowledge when students enter

universities (Silva et al., 2016). These skills are important tools in economics and finance subjects (Ross, 2023). Additionally, calculation is a necessity in accounting subjects. Students who can apply mathematical concepts to business problems and perform calculations accurately are more likely to succeed in these courses. This relationship is well documented in the literature (Lee & Lee, 2009). This analysis gives a more mixed result. There is a strong correlation between performance in mathematics and the exam grade in the introductory courses in economics, accounting, and marketing. Not surprisingly, there is a strong impact in microeconomics, since the presentation in this subject is largely a mathematical presentation. Students who do not master mathematics may have difficulty keeping up. The effect on the subject of law is in line with previous findings (Alcock et al., 2008). In principle, BL may require skills other than mathematics. The main reason why one can still demonstrate a correlation between mathematical abilities and performance in law subject may be that those who are proficient in mathematics use analytical or logical reasoning, focus on problem-solving, are more solution-oriented and pay attention to important details. These are skills that can contribute to success in BL.

Business students belong to a heterogeneous group with great variation in the composition of subjects. Some business students focus on fields other than quantitative subjects. Many non-quantitative subjects favour skills other than mathematical ones. This explains why business students who do not master mathematics well tend to choose non-quantitative majors (Opstad, 2019).

Perhaps somewhat surprisingly, this study shows no statistical correlation between performance in BM and the exam grade in advanced courses in economics, finance, accounting, and marketing (see MAFM, AMIE, FS, IFA and MAC, Tables 2–4). The picture is completely different in terms of skills in statistics. There is a strong positive correlation between performance in BS and success in business subjects. The effects tend to be greater for supplementary subjects than for the introductory subjects (with the exception of management courses). For macroeconomics, the value of the coefficient B is .467 in MAFM versus .275 in MAE (see Table 2). The same tendency is recorded for microeconomics, accounting, and marketing (see Tables 2–5). There are few studies that have looked directly at the connection between statistical skills and success in the various business subjects. However, the findings of this analysis confirm the assumption of Kirk and Spector (2006) that statistical skills are more linked to performance for business students than mathematical abilities. However, Kirk and Spector (2006) limited themselves to the analysis only of accounting subjects. Though there are few published articles that specifically address the correlation between business statistics and students' success in business subjects, there are papers that provide some valuable insights into the function of statistics in business education. According to Garfield and Ben-Zvi (2007), statistical knowledge improves ability in higher order thinking and reasoning and is essential for interpreting the use of empirical data. Undergraduates with strong statistical skills will probably tend to do better in understanding, interpreting, and analysing data. This can be a crucial factor for strategic decisions in various business disciplines. Furthermore, these students will improve their abilities to solve complex problems, evaluate investment opportunities, or assess risks. These are critical factors in some business domains—for instance, within finance and economics. The students will be more skilled in critical thinking, forecasting and predictive modelling. Strong statistical skills help the undergraduate to improve communications using statistical data. This will improve strategic planning. All of this may help explain the close connection between statistical ability and success in the various areas of business school. This

knowledge is perhaps even more important in the advanced courses. That may be the reason for the results in this analysis.

Statistical thinking is crucial for enhancing various tiers of an organisation, encompassing strategy, management, and operational systems (Snee ,1990). Notably, in the processing and analysis of big data that the business sector demands, proficiency in statistics is paramount. This suggests that expertise in statistics and mathematics not only contributes to superior academic performance but also serves as a valuable tool in the business world (Tolerado, (2019).

The Control Variables

There is a strong correlation between OM and further success. Undergraduates with a solid understanding of organizational behaviour may be better equipped to work effectively and communicate with others, which may be important in courses such as marketing, finance, and management. Besides, a good understanding of strategy may help students to analyse business problems and make informed decisions, which is important in many business courses. OM can also help students develop important skills such as critical thinking, problem solving, and communication. These skills are essential for success on business courses (D'Souza & Maheshwari, 2010).

Upper secondary school academic performance is important as an entrance ticket to higher education but is only to a limited extent connected to success in business education. There may be several reasons for this. Business studies favour specific skills, while upper secondary school focuses on a broad range of subjects. Additionally, there are significant differences in grading at different high schools in Norway. There is widespread use of additional points for age, military staff and more. Another important factor is that students have become more mature and changed their study habits. This may explain why the relationship between high school GPA and success decreases with the length of study in this research.

There is a lot of literature on gender and performance in business disciplines. There are some indications that traditional gender differences have narrowed (Ramirez & Lofgren, 2023). It is interesting to note that in this study there are several subjects where women do better than men rather than the other way around.

Conclusions and Further Research

This paper analyses the link between students' achievements in the two subjects mathematics and statistics and further success in business education. Similar to previous research, this study finds a strong link between mathematical skills and academic success, especially in introductory courses. At the bachelor level, relatively simple mathematics is applied, but it is an important instrument for good logical and analytical presentation This applies especially to quantitative subjects, but the impact is also significant for law. The link to success is much stronger for statistical skills than for mathematical ones, and impacts are greater for the advanced courses.

Mathematics and statistical skills seem to be predictors of success in business education. Business statistics provides students with a solid understanding of quantitative analysis, which is essential for understanding many business concepts. This understanding can help students to think critically and to approach complex business problems with more confidence. Business statistics are likely to have a solid foundation in the key skills that are

essential for success in many business fields. This may explain why the relationship with statistical skills increases throughout business education.

The data originates from a school that employs traditional teaching methods with a cohort of 100-200 students, complemented by a range of exercises. It would be intriguing to explore the impacts of alternative teaching approaches, smaller class sizes, and more intensive monitoring.

It is desirable to have more studies that analyse this and that also include master students. It is interesting to see if other studies can confirm the results in this analysis.

Another important follow-up is to see if the students' better knowledge in mathematics and statistics also contributes to greater success in the practical business world.

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Is performance in Mathematics and Statistics related to Success in Business Education?

Abstract

Purpose-The purpose of the article is to gain more insight into factors that can explain students' success in business subjects. The focus is on the connection between performance in introductory courses in business mathematics and business statistics and success in various business subjects.
Design/methodology/approach-Use of a regression model with administrative data from a business school in Norway over a period of 10 years.
Findings- The findings show a strong correlation, especially in quantitative subjects. The results suggest that statistical skills are more strongly related to academic success than mathematical skills.
Research limitation/implications- Data are collected from only from one school. No information on undergraduates' personality and behaviour is available.
Originality/value- There are limited published studies that have explored the relationship between success in statistics and later achievements in business courses. This is useful knowledge for planning the content of the bachelor's programme.
Keywords: business education, performance, regression model, statistical skills, mathematical skills

Introduction

Introductions to business statistics and business mathematics are compulsory courses in many undergraduate programmes for business students. Both subjects are believed to be important instruments and tools for achievement in business subjects. Though there is some overlap between the two, they have different focuses. Mathematics deals with the study of numbers, quantities, and shapes. It includes areas such as algebra, geometry, calculus, and topology. Mathematics can solve problems related to finance, accounting, and economics. The tool can help to calculate costs and find the optimal pricing strategy for a product. Undergraduates who can use mathematical thinking in business problems and perform calculations accurately tend to succeed in business education. There are many published articles that have studied the link between mathematical background and skills and performance in economic and business subjects (Alcock et al., 2008; Arnold & Straten, 2012; Lee & Lee, 2009).

Few studies have investigated the relationship between statistical skills and success in business subjects, even though statistics is a key subject for economics and business students. An exception is the subject of accounting. Statistics focuses on collecting, analysing, and interpreting data. It includes descriptive statistics, probability theory, and inferential statistics. Statistics is helpful to consider risk, test hypotheses, and make predictions. Research shows a strong relationship between mathematical abilities and performance in business statistics (Johnson & Kuennen, 2006; Noser et al., 2008). However, Opstad (2022a) does not find any significant association. Students who have a solid foundation in statistics and can apply statistical concepts to real-world business problems are more likely to succeed in many business courses. Several researchers have analysed the importance of statistics for final grades in accounting-related subjects (Kirk & Spector, 2006; Onay & Benligiray, 2018). On the other hand, many studies have analysed how the GPA (grade point average) from upper secondary school or the first year of an undergraduate programme influences further performance (Bacon & Bean, 2006; Damianov et al., 2009; Jones et al., 2013).

This article stands out from earlier research in that it simultaneously examines how presentations in both statistics and mathematics are linked to further success in the various business subjects. As an indicator of success in business education, this study uses the grades achieved in exams for the various subjects. Several authors emphasize that the teaching method and attitudes towards the subject are of great importance in determining whether students succeed (Sharma & Srivastav, 2021). This topic is not discussed in this article.Good exam grades are related to success in working life (Westerman et al., 2012). Hence, it is useful to know which factors contribute to good performance in business courses.

Mathematical Skills and Hypothesis

Mathematical skills are important for lot of fields within higher education (Joyce et al., 2017). This includes business education (Asian-Chaves et al., 2021). Mathematics knowledge enables students to structure and analyse relationships. Such skills make one a more proficient business economist. Based on economic theory, one can expect a positive connection between mathematical skills and performance in business subjects. There are many published articles that confirm such a relationship.

Basic knowledge is regarded as necessary to achieve high academic performance in business fields, especially in quantitative courses (Opstad,2018). Anderson et al. (1994) reported a positive association between having taken calculus and students' performance in microeconomics. Other researchers have confirmed that mathematical skills are a key predictor for success in an introductory economic class (Ballard & Johnson, 2004; Mallik & Basu, 2009). This explains why studying more mathematics at upper secondary school helps students to increase their performance in economics courses at university level (Asian-Chaves et al., 2022). Alcock et al. (2008) suggested a significant positive relationship between mathematical skills and performance in both micro- and macroeconomics, but with a stronger impact for microeconomics.

In other quantitative courses such as finance, the research shows similar results (Ely & Hittle, 1990; Grover et al., 2009; Ross et al., 2020; Uyar & Güngörmüş, 2011). According to Guidry (2020), students who struggle with mathematics will face substantial challenges managing advanced courses in financial analysis.

The findings around the link between mathematical skills and success in accounting courses are mixed. Guney (2009) and Kealey et al. (2005) reported a positive relationship between mathematical abilities and performance on accounting courses. Other researchers do not find mathematics to have any influence on achievements in accounting (Benligiray & Ahmet, 2017).

Management-oriented subjects differ from quantitative courses. They require a higher degree of verbal and organizational skills (Bartlett et al., 1993; Benligiray & Ahmet, 2017). Hence, mathematical and quantitative abilities are less important for success in such subjects. Even so, Brookshire and Palocsay (2005) found a positive correlation between performance in mathematics and success on management courses. However, there are many indications that the field of business law stands out (Alcock et al., 2008). An explanation may be that a strong mathematical background make students better at handling problem-solving and higher order logic. Hence, they perform better in law studies.

Hypothesis 1(H1): Students' success in business subjects is related to mathematical skills.

Statistical Skills and Hypothesis

in the various business disciplines, students learn to analyse uncertainties and process available data. Being able to do this systematically and strategically is crucial for success in the workplace. An introductory course in statistics is a key factor in developing analytical skills and applying numerical data to conduct meaningful analyses (Hsu et al., 2021). Therefore, Hoerl and Snee (2020) emphasise that if students receive training in statistical thinking, they will become more proficient business economists. Statistical knowledge equips students with the tools they need to interpret, analyse, and effectively use data in various business contexts.

Statistical knowledge can provide a better theoretical foundation for achieving good performance in various subjects at business schools, from quantitative subjects like finance, to more qualitative courses like marketing and organisational theory. In the business world, decision-making is often based on data and analysis. Statistical knowledge enables students to evaluate risk, make forecasts, and identify opportunities In marketing, understanding consumer behaviour and market analysis are essential. Statistical tools such can be applied to optimise marketing strategies. In finance, statistics are vital for risk management, and portfolio optimization. Students can use statistics to evaluate securities, calculate risk and return, and make informed investment decisions.

Kirk and Spector (2006) suggested a positive link between success in statistics and performance on accounting courses, but they could not detect a similar connection between mathematics and these subjects.

Marcal and Roberts (2001) reported a significant positive relationship between statistical abilities and achievement on finance courses. Brookshire and Palocsay (2005) did not find any significant connection between statistical abilities and achievement on management courses.

Hypothesis 2(H2): Students' success in business subjects is related to statistical skills.

Data and Methods

The analysis is based on administrative data from a business school in Scandinavia over a period of ten years (2010–2019). For compulsory subjects, the number of observations per year is about 200. Some of the subjects are voluntary, or the subject has been offered only in a limited way. This explains why for some of the subjects there are few observations (see Table 1). There are also examples of some subjects with access to data only for a more limited period. In these cases, the number of observations is given in parentheses. In any case, the figures are so large that they provide a good basis for closer analysis. Table 1 presents descriptive statistics of all the variables used in this study.

Table 1. Descriptive statistics

	Mean	SD
Gender (0:F, 1:M)	.49	.50
GPA (grade point average, upper secondary school)	52.9	3.78
Business subjects and final grades[1]		
Organizations and Management (OM) 1st year	3.07	1.07
Business Mathematics (BM) 1st year	3.29	1.30
Business Statistics (BS) 1st year	3.35	1.26
Microeconomics (MIE) 1st year	3.21	1.12
Macroeconomics (MAE) 2nd year	2.91	1.29
Macroeconomics and Finance Market (MAFM) (N=268) 3rd year	3.58	1.09
Applied Microeconomics (AMIE) (N=258)	3.48	1.02

Financial Accounting (FA) 1st year	3.42	1.25
Cost Accounting (CA) 2nd year	3.32	1.42
Financial Statements (FS) (N=191) 3rd year	3.58	1.25
Investment and Financial Analysis (IFA) (N=557) 2nd year	3.32	1.21
Quantitative and Qualitative Methods (QQM)(N=839) 3rd year	3.35	1.26
Marketing Basis Course (MABC) 1st year	2.89	.96
Marketing Communication (MAC) (N=643) 3rd year	3.31	1.01
Ethics and Social Responsibility (ESR)(N=770) 3rd year	3.39	1.03
Business Law (BL) (N=796) 2nd year	3.02	1.02
Business Strategy (BSt) 2nd year	3.02	1.04
Leadership (LS)(N=393) 3rd year	3.32	1.07
Organizational Psychology (OP) (N=635) 3rd year	2.94	.97

Note: [1] Final grades 1: E, 2: D, 3: C, 4: B, 5: A

(F is not included)

In this project, a standard linear regression model is used where the exam grade in the different business subjects is the dependent variable. As explanatory variables, the focus is on performance in the two introductory subjects, business mathematics (BM) and business statistics (BS). The first subject is offered in the first semester (in the autumn) and the next in the second semester (spring), Hence, only subjects taken either in the second semester or later in the bachelor programme are included in this analysis. In this study, it is assumed that performance in mathematics and statistics is an indicator of skills in these two subjects.

Control Variables

Many studies report that GPA and gender influence students' achievements. There is a significant difference between the GPA from upper secondary school, which is the criterion for accessing the programme, and the GPA the first year after arriving on campus. Published articles suggest that GPA from upper secondary school is positively related to achievements in business studies (Abdullah, 2011; Alhajraf & Alasfour, 2014 Cyrenne & Chan, 2012; Sulphey et al., 2018). Since GPAs determine who gets the entry ticket, it is not surprising that those who have high scores at intake also perform well in various subjects. Especially with cumulative knowledge, the first year GPA is a good predictor for further success. Fundamental understanding is covered in the early part, and students' performance in further courses depends on how they manage the introduction courses (Guidry, 2020). D'Souza and Maheshwari (2011) provide evidence that current GPA scores are positively related to students' performance in management science courses. Borde (2007) suggests that undergraduate GPS is a better indicator of success in a business finance course than GMAT (The Graduate Management Admission Test) scores. Al-Rashed (2001) found GPA to be the strongest factor to predict performance in accounting subjects. Brookshire and Palocsay (2005) came to the same result regarding management courses. First year GPA seems to be a good predictor of further success in business subjects (Opstad, 2022b; Parrish, 2013).

There has been a lot of research on the link between gender and performance in economic and administrative subjects. The research shows mixed and contradictory results. Kim et al. (2022) suggested that men perform better than women, especially in quantitative courses. This is consistent with the finding of Krishna and Orhun (2022). Other studies

conclude that female students have higher success than male students (Corpuz et al., 2022; Ezenwafor et al., 2022). There are published papers reporting no or only a minor gender gap (Papageorgiou & Halabi, 2014; Schmidt et al., 2022).

In this study, we use gender, GPA from upper secondary school, and performance in Organizations and Management (OM) as control variables. Organizations and Management is an introductory course (first semester) that provides students with a foundation in the principles and practices of management. This course, taken by students in their first year of business studies, probably has a significant impact on their success in subsequent business courses. It helps students to develop a broad understanding of the various functions of business and the ways in which they are interconnected. OM introduces the undergraduates to concepts such as organizational behaviour, strategy, and leadership. Those components are important for success in other business courses. This is a non-quantitative course. It rewards students who are proficient in verbal presentation.

There is intense competition for admission to the business school referenced in this study. The age difference is minimal, with most students being just over 20 years old. No data is available regarding whether the students have prior work experience, have undertaken other education, or have completed military service before enrolling in this programme. **Results**

Business Mathematics

Performance in BM is positively correlated with success in many business subjects, but the results are mixed. The effect is strong for the introduction courses in economics, but the impact is small and not significant for the advanced courses in the same subject, see Table 2. (cf. MAFM (Macroeconomics and Finance Market) and AMIE (Applied Microeconomics)). The same tendency applies to accounting courses (Table 3). Students' performance in BM is strongly related to the exam grade in accounting courses like FA (Financial Accounting) and CA (Cost Accounting), but not FS(Financial Statements). For the finance subject IFA(Investment and Financial Analysis) and the methodology subject QQM (Quantitative and Qualitative Methods), there is no significant correlation with BM (Table 4). Of the non-quantitative subjects (Tables 5 and 6), a positive significance effect is registered only in relation to the introductory course in marketing (MABC) and law (BL). Hypothesis 1 is partially confirmed.

Table 2. Regression model: economics courses as dependent variables

Variables	Microeconomics (MIE)		Macroeconomics (MAE)		Macroeconomics and Finance Market (MAFM)		Applied Microeconomics (AMIE)	
	B	T-value	B	T-value	B	T-value	B	T-value
Gender	.010	.415	.095	3.51***	.295	3,96***	-.172	-2.61*
GPA	.077	3.10**	.098	3.50***	.025	.33	.018	.28
OM	.176	6.98***	.204	7.28***	.177	2.23*	.178	2.66**
BM	.284	10.13***	.188	6.03***	.068	.83	.088	1.16
BS	.350	12.53***	.275	8.29***	.457	5.53***	.454	6.05***
Adj,R^2	382		.261		.361		.333	
N	1 035		1 003		119		156	

* P<.05, **:P<.01, *** P<.001. Standardized coefficients B. Accepted level of variance inflation factor (VIF).

Table 3. Regression model: accounting courses as dependent variables

Variables	Financial Accounting (FA)		Cost Accounting (CA)		Financial Statements (FS)	
	B	T-value	B	T-value	B	T-value
Gender	-.042	-1.55	.056	1.86	-.074	-.63
GPA	.108	3.88***	.078	2.57*	-.060	-.50
OM	.184	6.47***	.139	4.43***	.268	2.18*
BM	.206	6.45***	.200	5.72***	.156	1.20
BS	.281	8.85***	.314	8.92***	.357	2.63*
Adj,R^s	.268		.262		.266	
N	973		814		55	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Business Statistics

BS is significantly positively correlated with the business courses included in this analysis. The impact is particularly strong for finance (Table 4) and advanced courses in economics (Table 2) but also notable for the non-quantitative subjects except for Leadership (Table 5 and 6). Hypothesis 2 is confirmed.

Table 4. Regression model: finance and methods courses as dependent variables

Variables	Investment and Financial Analysis (IFA)		Quantitative and Qualitative Methods (QQM)	
	B	T-value	B	T-value
Gender	.161	2.57*	-.074	-1.34
GPA	-.026	-.40	.006	.10
OM	.149	2.28*	.181	3.12**
BM	.133	1.82	.043	.67
BS	.412	5.59***	.302	4.59***
Adj,R^s	.277		.162	
N	175		274	

* P<.05, ** P<.01, *** P<.001. Standardized coefficients B. Accepted level of VIF.

Table 5. Regression model: mixed non-quantitative courses as dependent variables

Variables	Marketing Basis Course (MABC)		Marketing Communication (MAC)		Ethics and Social Responsibility (ESR)		Business Law (BL)	
	B	T-value	B	T-value	B	T-value	B	T-value
Gender	-.066	-2.40*	-.210	-3.29**	-.158	-2.82*	-.148	-2.55*
GPA	.053	1.90	.053	.83	.042	.73	.100	1.72
OM	.383	13.45***	.264	3.98***	.123	2.09*	.147	2.47*
BM	.129	4.08***	.003	.04	.075	1.14	.157	2.37*
BS	.105	3.31***	.194	2.66**	.212	3.18**	.213	3.17**

Adj,R^s	.233	.163	.115	.176
N	1 011	211	282	250

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

Table 6. Regression model: management courses as dependent variables.

Variables	Business Strategy (BSt)		Leadership (LS)		Organizational Psychology (OP)	
	B	T-value	B	T-value	B	T-value
Gender	-.078	-2.52*	.111	1.01	-.181	-2.80**
GPA	-.084	-2.68**	-.025	-.22	.155	2.38*
OM	.265	8.26***	.258	2.21*	.201	3.00**
BM	.033	.92	.105	.87	.014	.185
BS	.216	5.91***	-.094	-.76	.198	2.63**
Adj,R^s	.152		.021		.158	
N	881		84		204	

* P<.05, **: P<.01, ***: P<.001. Standardized coefficients B. Accepted level of VIF.

The Control Variables

Achievement in the introductory course in management (OM) is significantly positively correlated with exam grades for all business subjects in this study. The impact is strong for both the quantitative and the non-quantitative courses.

When it comes to GPA from upper secondary school, the results are mixed. There is a positive significant relationship to success in only five of the subjects, The impact is most marked for the introductory courses. For BSt, the impact is negative. For most of the subjects (9 out of 16), GPA has no significant effect.

For some of the subjects, there are significant outcomes regarding gender. The following subjects favour men: MAE, MAFM, IFA. They are all quantitatively oriented courses. In the subjects AMIE, MABC, MAC, ESR, BL, BSt and OP, the women come out on top.

The regression models have an acceptable level of adjusted R^2, the models explaining between 10 and 30 per cent of variability in the dependent variables with exception of LS.

Discussion

Statistics and Mathematics

This study confirms previous research finding that students who perform well in their first year of higher education are more likely to continue to do well in subsequent years (Crowther & Briant, 2021). In this investigation, only a selection of subjects from the first year is included. The focus is on the connection between achievements in mathematics and statistics and undergraduates' further success in business education. This analysis confirms and documents that it is highly sensible to have mandatory introductory courses in mathematics and statistics at the bachelor's level for business students.

Business mathematics is essential for success in many business courses. Despite this, some authors report a decline in mathematical and statistical knowledge when students enter universities (Silva et al., 2016). These skills are important tools in economics and finance subjects (Ross, 2023). Additionally, calculation is a necessity in accounting subjects. Students

who can apply mathematical concepts to business problems and perform calculations accurately are more likely to succeed in these courses. This relationship is well documented in the literature (Lee & Lee, 2009). This analysis gives a more mixed result. There is a strong correlation between performance in mathematics and the exam grade in the introductory courses in economics, accounting, and marketing. Not surprisingly, there is a strong impact in microeconomics, since the presentation in this subject is largely a mathematical presentation. Students who do not master mathematics may have difficulty keeping up. The effect on the subject of law is in line with previous findings (Alcock et al., 2008). In principle, BL may require skills other than mathematics. The main reason why one can still demonstrate a correlation between mathematical abilities and performance in law subject may be that those who are proficient in mathematics use analytical or logical reasoning, focus on problem-solving, are more solution-oriented and pay attention to important details. These are skills that can contribute to success in BL.

Business students belong to a heterogeneous group with great variation in the composition of subjects. Some business students focus on fields other than quantitative subjects. Many non-quantitative subjects favour skills other than mathematical ones. This explains why business students who do not master mathematics well tend to choose non-quantitative majors (Opstad, 2019).

Perhaps somewhat surprisingly, this study shows no statistical correlation between performance in BM and the exam grade in advanced courses in economics, finance, accounting, and marketing (see MAFM, AMIE, FS, IFA and MAC, Tables 2–4). The picture is completely different in terms of skills in statistics. There is a strong positive correlation between performance in BS and success in business subjects. The effects tend to be greater for supplementary subjects than for the introductory subjects (with the exception of management courses). For macroeconomics, the value of the coefficient B is .467 in MAFM versus .275 in MAE (see Table 2). The same tendency is recorded for microeconomics, accounting, and marketing (see Tables 2–5). There are few studies that have looked directly at the connection between statistical skills and success in the various business subjects. However, the findings of this analysis confirm the assumption of Kirk and Spector (2006) that statistical skills are more linked to performance for business students than mathematical abilities. However, Kirk and Spector (2006) limited themselves to the analysis only of accounting subjects. Though there are few published articles that specifically address the correlation between business statistics and students' success in business subjects, there are papers that provide some valuable insights into the function of statistics in business education. According to Garfield and Ben-Zvi (2007), statistical knowledge improves ability in higher order thinking and reasoning and is essential for interpreting the use of empirical data. Undergraduates with strong statistical skills will probably tend to do better in understanding, interpreting, and analysing data. This can be a crucial factor for strategic decisions in various business disciplines. Furthermore, these students will improve their abilities to solve complex problems, evaluate investment opportunities, or assess risks. These are critical factors in some business domains—for instance, within finance and economics. The students will be more skilled in critical thinking, forecasting and predictive modelling. Strong statistical skills help the undergraduate to improve communications using statistical data. This will improve strategic planning. All of this may help explain the close connection between statistical ability and success in the various areas of business school. This knowledge is perhaps even more important in the advanced courses. That may be the reason for the results in this analysis.

Statistical thinking is crucial for enhancing various tiers of an organisation, encompassing strategy, management, and operational systems (Snee ,1990). Notably, in the processing and analysis of big data that the business sector demands, proficiency in statistics is paramount. This suggests that expertise in statistics and mathematics not only contributes to superior academic performance but also serves as a valuable tool in the business world (Tolerado, (2019).

The Control Variables

There is a strong correlation between OM and further success. Undergraduates with a solid understanding of organizational behaviour may be better equipped to work effectively and communicate with others, which may be important in courses such as marketing, finance, and management. Besides, a good understanding of strategy may help students to analyse business problems and make informed decisions, which is important in many business courses. OM can also help students develop important skills such as critical thinking, problem solving, and communication. These skills are essential for success on business courses (D'Souza & Maheshwari, 2010).

Upper secondary school academic performance is important as an entrance ticket to higher education but is only to a limited extent connected to success in business education. There may be several reasons for this. Business studies favour specific skills, while upper secondary school focuses on a broad range of subjects. Additionally, there are significant differences in grading at different high schools in Norway. There is widespread use of additional points for age, military staff and more. Another important factor is that students have become more mature and changed their study habits. This may explain why the relationship between high school GPA and success decreases with the length of study in this research.

There is a lot of literature on gender and performance in business disciplines. There are some indications that traditional gender differences have narrowed (Ramirez & Lofgren, 2023). It is interesting to note that in this study there are several subjects where women do better than men rather than the other way around.

Conclusions and Further Research

This paper analyses the link between students' achievements in the two subjects mathematics and statistics and further success in business education. Similar to previous research, this study finds a strong link between mathematical skills and academic success, especially in introductory courses. At the bachelor level, relatively simple mathematics is applied, but it is an important instrument for good logical and analytical presentation This applies especially to quantitative subjects, but the impact is also significant for law. The link to success is much stronger for statistical skills than for mathematical ones, and impacts are greater for the advanced courses.

Mathematics and statistical skills seem to be predictors of success in business education. Business statistics provides students with a solid understanding of quantitative analysis, which is essential for understanding many business concepts. This understanding can help students to think critically and to approach complex business problems with more confidence. Business statistics are likely to have a solid foundation in the key skills that are essential for success in many business fields. This may explain why the relationship with statistical skills increases throughout business education.

The data originates from a school that employs traditional teaching methods with a cohort of 100-200 students, complemented by a range of exercises. It would be intriguing to explore the impacts of alternative teaching approaches, smaller class sizes, and more intensive monitoring. It is desirable to have more studies that analyse this and that also include master students. It is interesting to see if other studies can confirm the results in this analysis.

Another important follow-up is to see if the students' better knowledge in mathematics and statistics also contributes to greater success in the practical business world.

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