INTERNATIONAL STUDENT ANALYTICS AND FORECASTING MODEL (ISAFM)

Province of British Columbia &

Capilano University, Okanagan College & Simon Fraser University

Pilot Release

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International Student Analytics and Forecast Model™.

ACKNOWLEDGEMENTS

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ICG would also like to acknowledge the three pilot institutions – Capilano University, Okanagan College, and Simon Fraser University – for their cooperation and assistance in this pilot release.

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INTRODUCTION TO ISAFM

Background

Welcome to the pilot release of ICG's International Student Analytics and Forecast Model (ISAFM) on behalf of the British Columbia Council for International Education (BCCIE). ISAFM has been a collaborative, multi-disciplinary, and multi-year effort rooted in the doctoral research of ICG's Managing Director, Dr. Daniel J. Guhr.

ISAFM was conceived as a tool for introducing evidence-based, expert-derived analytical rigor into the comprehensive analysis and forecasting of international (higher education) student flows.

With the latter heading towards four million students enrolled outside their home country – and an economic impact of around USD 80 billion annually – educating international students around the globe has become an industry which requires industrial-strength research, analysis, and forecasting.

ISAFM Properties

By considering gender, subject matter (study field), and degree level, ISAFM predicts student enrollments at a granular level three years into the future. If data allows, ISAFM can operate with a matrix of these sub-variables, thereby allowing for unprecedented student pool segmentation.

ISAFM considers both the external student supply landscape as well as the internal (client) national, state/provincial, or institutional demand landscape.[1] By matching the former to the latter based on capacity, capability, and policy as well as strategic development parameters, ISAFM steps away from a mere normative supply-based model. Instead, it interprets the model-based forecast using the mentioned parameters and delivers policy and strategy advice rather than just a data file.

This release of ISAFM (1.1) is based on more than 1.9 million data points, and more than 120 variables organized in five major categories. The key countries also covered in-depth in the model account for more than 80% of in-coming and out-going international students worldwide.

[1] N.B. Common usage inverts this supply and demand nomenclature which we belief to be a mischaracterization of actual market dynamics.

The current release, which contains all structural properties of subsequent planned release versions, marks an intermediate step on the way to a fully integrated System Dynamics-based analytical model which ICG aims to release in the fall of 2012.

ISAFM Limitations and Responses

ISAFM as an analytical and predictive modeling tool does not claim to be perfect. Gaps in publicly available data, the broad scope of ISAFM, and inherent uncertainties about the development of the world three years into the future introduce methodological challenges which even the best model cannot solve completely. As a response, ISAFM is employing a wide array of statistical and forecasting methods to reduce errors and variability as much as possible.

ICG is also developing Scenarios as a response to the fact that ISAFM is not geared towards forecasting disruptive events such as pandemics, civil wars, major economic crises, and so on. These Scenarios are based on subsets of data of the overall ISAFM data model and focus on predicting the impact of such events on student flows.

A third response is based on the ISAFM development roadmap ICG has created which addresses data and modeling aspects of ISAFM which will be further developed until the fall of 2012 with the planned release of Version 1.4.

ISAFM: Entering the Age of Analytics in International Education

ISAFM's mission is as simple as it is ambitious: To assist in ushering in the age of analytics in international education. On behalf of ICG and the entire ISAFM Team, I look forward to this journey.

Yours sincerely,

Dr. Daniel J. Guhr
Managing Director, ICG

ISAFM TEAM

A Long-term, Multi-facetted, Collaborative Effort

The development of ISAFM has its roots in the doctoral research of ICG's Managing Director, Dr. Daniel J. Guhr. This research dates back to the mid-1990s when he began to collect and analyze large amounts of educational data relating to higher education access in Germany and California.

Dr. Guhr pursued his dissertation research at the University of Oxford, the Center for Studies in Higher Education at the University of California at Berkeley, and the Max-Planck-Institute for Human Studies in Berlin. During this time, he was fortunate to be able to work with leading researchers whose insights continue to guide ISAFM's intellectual framework.

ISAFM's analytical design has also been influenced by Dr. Guhr's experiences with the Boston Consulting Group and SAP between 1997 and 2001. Both companies added to Dr. Guhr's understanding of process excellence, data analysis, and the organization of large project teams.

An important component of ISAFM's development is the expert network ICG has built since 2003. This network has contributed perspectives on the nature and validity of structural and analytical aspects of ISAFM for a number of years.

ISAFM's conceptual framework was finalized in the fall of 2009. Subsequent, members of ICG's Research Team began to collect data and conduct contextual research on issues ranging from educational policy-making to System Dynamics. In 2010, the ISAFM Advisory Board was formed and has come to include more than a dozen experts on salient international education issues.

In early 2011, the ISAFM Modeling Team was recruited at Stanford University. At the same time, ICG began a research partnership with the System Dynamics Group at the University of Bergen.

ISAFM has been and will continue to be a collaborative effort by many parties contributing to what may well be the most ambitious analytical model in international education.

ISAFM Research Team

Dr. Daniel J. Guhr

Dr. Guhr serves as ICG's Managing Director. Prior to founding ICG, he served as a strategy consultant with the Boston Consulting Group and as a Director of Business Development with SAP in Silicon Valley.

Dr. Guhr holds a D.Phil. in Higher Education and a M.Sc. in Educational Research Methodology from the University of Oxford, as well as a M.A. in Political Science from Brandeis University. Dr. Guhr was also trained in political science at Bonn and Harvard Universities, served as a research specialist at the University of California at Berkeley, and conducted research at the Max-Planck-Institute for Human Studies in Berlin.

During his studies, he was awarded 17 scholarships and grants. Dr. Guhr has authored more than 30 research papers and studies. His doctoral dissertation on *Access to Higher Education in Germany and California* was published in the Series *Studies in Comparative Education*.

Dr. Guhr is the past President of the Oxford University Society's San Diego branch. He also served on the Board of Bonn University's Universitätsgesellschaft. He currently serves on the Council of the University of California at Santa Cruz's College Eight.

Simon Lange, MPP

Mr. Lange serves as a researcher and analyst with ICG. Prior to joining ICG, he completed internships and part-time work in policy advisory think tanks and the media sector in Germany and the US.

Mr. Lange holds a MPP from the Hertie School of Governance in Berlin and a B.A. in British and American Studies from the University of Bielefeld in Germany. Mr. Lange was also trained in social sciences and policy analysis at Indiana State University and the National University of Singapore's Lee Kuan Yew School of Public Policy.

Mr. Lange has contributed to numerous ICG reports and presentations, including serving as lead analyst for the *International Student Sector and Immigration Pathways* report.

Grace Gair (MPP '11)

Ms. Gair serves as the Head of ICG Europe in Berlin. Prior to joining ICG, she received a one-year Fulbright scholarship to South Korea where she worked on English language training strategies and curriculum development with the Daejeon Ministry of Education.

Ms. Gair will graduate with a MPP from the Hertie School of Governance in Berlin in May 2011. Her ICG-sponsored thesis focuses on the introduction of tuition fees for non-EEA students in Sweden. Ms. Gair obtained a B.A. (Honors) from Eckerd College in the United States.

Ms. Gair served as a Ford scholar while at Eckerd College where she also served as President of the student body. In addition, she was selected as a Presidential Fellow for the Association of Independent Colleges and Universities of Florida.

Mauro Mondino (MPP '11)

Mr. Mondino serves as the Head of ICG's Research Team. Prior to joining ICG, he served as the International Officer of the JEF Italy Executive Bureau where he worked on civil society organizations and institutional reform in Europe.

Mr. Mondino will graduate with a MPP from the Hertie School of Governance in Berlin in May 2011. His ICG-sponsored thesis focuses on international flagship scholarships programs in a dozen countries. In 2010, Mr. Mondino served as a summer intern with ICG.

Mr. Mondino obtained a B.A. (cum laude) from the Catholic University in Milan, and also studied at the University of Denver.

ISAFM Modeling Team

Andrea A. Abel (Ph.D. '11)

Ms. Abel is currently completing her Ph.D. in Political Science at Stanford University. She holds a M.A. in Political Science from Stanford University, as well as an M.Eng. in Mechatronic Engineering and B.Sc. degrees in Aerospace Engineering and Commerce from the University of Sydney. During the course of her engineering studies, she served as a research associate at the German Aerospace Research Center.

Ms. Abel holds a Ph.D. fellowship from Stanford University. Prior to this she held an Australian Post Graduate Award from the Department of Education in Australia for her Master's studies, and a Faculty of Engineering Scholarship from the University of Sydney.

She has authored more than a dozen conference publications. She also served as editor of the textbook *Bayesian Analysis for the Social Sciences* which was published in the *Wiley Series on Probability and Statistics*.

Ms. Abel is proficient in several languages including Hungarian, German, Japanese and Russian, and holds a private pilot's license with the Federal Aviation Authority in Australia.

Michael Bailey (Ph.D. '12)

Mr. Bailey is pursuing a Ph.D. in Economics at Stanford University with a focus on applied econometrics. At Stanford, he has taught or co-taught courses in corporate strategy and microeconomic theory.

He holds a B.A. in Mathematics (summa cum laude) and a B.A. in Economics (summa cum laude) from Utah State University. During his undergraduate studies he was the chief data analyst at the Institute for Antiviral Research where he co-authored several statistical reports for the National Institute of Health.

Mr. Bailey was awarded several scholarships and awards, including a Stanford University Ph.D. fellowship, "Scholar of the Year" at Utah State University, the William Wanlass fellowship in economics, the State of Utah Science Scholarship, the Rae N. and Orson A. scholarship, and a Seely-Hinckley Fellowship. He was also the Phi Beta Lambda national champion in economic analysis.

Carlos Fernandez-Granda (Ph.D. ’13)

Mr. Fernandez-Granda is working on a Ph.D. in Electrical Engineering at Stanford University. He holds a M.Sc. in Applied Mathematics from the École Normale Supérieure in Paris, a Master’s in Civil Engineering from the École des Mines in Paris, and was also educated in Electrical Engineering and Computer Science at the Universidad Politécnica in Madrid.

During his studies, Mr. Fernandez-Granda received the Graduate Fellowship from the La Caixa Foundation. He was also a three time recipient of the Madrid Scholarship for Academic Excellence in university studies.

Mr. Fernandez-Granda held analyst positions in academia and the energy and health sectors in France, Germany, and Spain. He is proficient in several languages including Chinese, English, French, German, Spanish, and Russian.

Orhun Aydin (M.Sc. ’12)

Mr. Aydin is pursuing a M.Sc. in Petroleum Engineering at Stanford University. He holds a B.Sc. in Petroleum and Natural Gas Engineering from the Middle East Technical University.

During his studies, Mr. Aydin received the STAR Fellowship from the Society of Petroleum Engineers. He is also a four time recipient of the Dean’s Outstanding Student Award from the Engineering Department of the Middle East Technical University.

Mr. Aydin held research assistant positions at Stanford University and the Middle East Technical University in Ankara.

ISAFM Advisory Board Members

- Bjorn Einar Aas. Senior Advisor in the Department of Research Management at the University of Bergen, Norway, and past President of the European Association for International Education.
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- Paul Brennan. Vice-President for International Partnerships at the Association of Canadian Community Colleges, Canada.
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- Markus Laitinen. Head of International Affairs at the University of Helsinki, Finland.
- Sonny Lim, JD. Director of International Relations at Nanyang Technological University, Singapore.
- Chris Madden. Pro Vice Chancellor (International) at Griffith University, Australia, and Steering Committee as well as Board of Directors member of Asia Pacific Association for International Education.
- Joy McKinnon, DBA. Vice President of Business Development at Algonquin College, Canada.
- Gonzalo Peralta. Executive Director of Languages Canada, Canada, and pat President of the Association de l'industrie de la langue.
- Prof. Chris Robinson. Associate Dean, International at Victoria University, Australia, and the inaugural Managing Director of Universitas 21.
- Richard Stenelo. Director of Commissioned Education at Lund University, Sweden.
- Delia de Vreeze. International Marketing Manager at Wageningen University, The Netherlands, and General Council member of the European Association for International Education.

ISAFM Research Partners

System Dynamics Group at the University of Bergen

Prof. Pål Davidsen

Prof. Pål Davidsen serves as Professor of System Dynamics at the Department of Geography at the University of Bergen (UiB). He is a former president of the System Dynamics Society. Prior to that, he held adjunct faculty positions at Chalmers University, Mikkeli Polytechnic Institute, the Massachusetts Institute of Technology, and the University of Karlstad.

Prof. Pål Davidsen holds a Mag. Art. from the Department of Information Science at the University of Bergen. Since 1983, he has served as an associate professor and professor in the Department of Information Science and the Department of Geography at the University of Bergen.

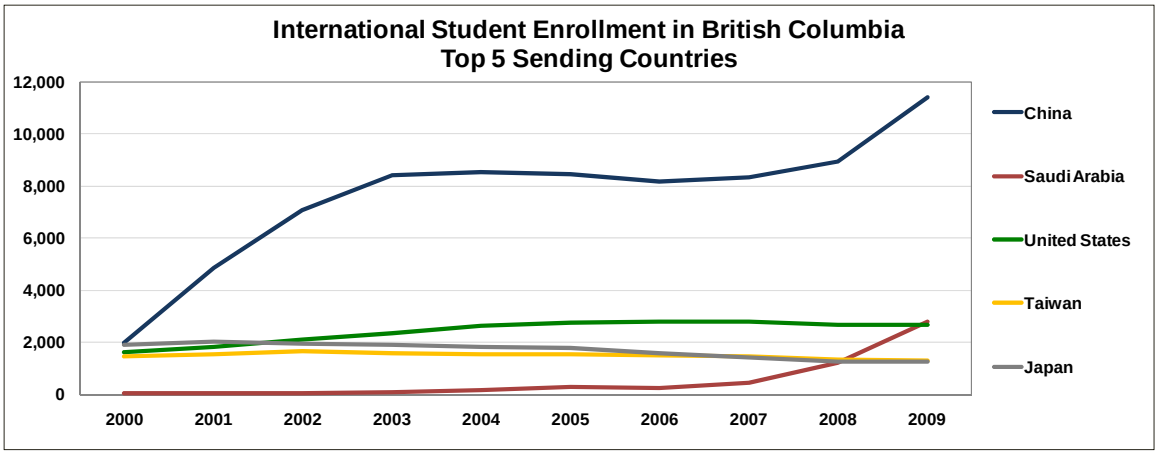
Prof. Pål Davidsen served as President of the System Dynamics Society and Managing Editor of the System Dynamics Review. He also served on more than a dozen academic and professional groups and committees, including the Interim Board of the Norwegian Council for Information Science and the Curriculum Committee of the System Dynamics Society.

BRITISH COLUMBIA INTERNATIONAL EDUCATION LANDSCAPE

International Student Enrollment Trends

Between 2000 and 2009, total international student enrollment in British Columbia increased from 13,220 to 31,979.[2] As shown in the graph below, enrollment growth was largely driven by a strong increase in Chinese students between 2000 and 2003 (327.0 percent growth), and a second wave of enrollment growth of Chinese and Saudi Arabian enrollments in 2008 and 2009.

International Higher Education Student Enrollment in British Columbia by Top 5 Sending Countries (Total)



Notes: Data denote international students in CIC's "University" and "Other Post-Secondary" education segments.
Source: CIC.

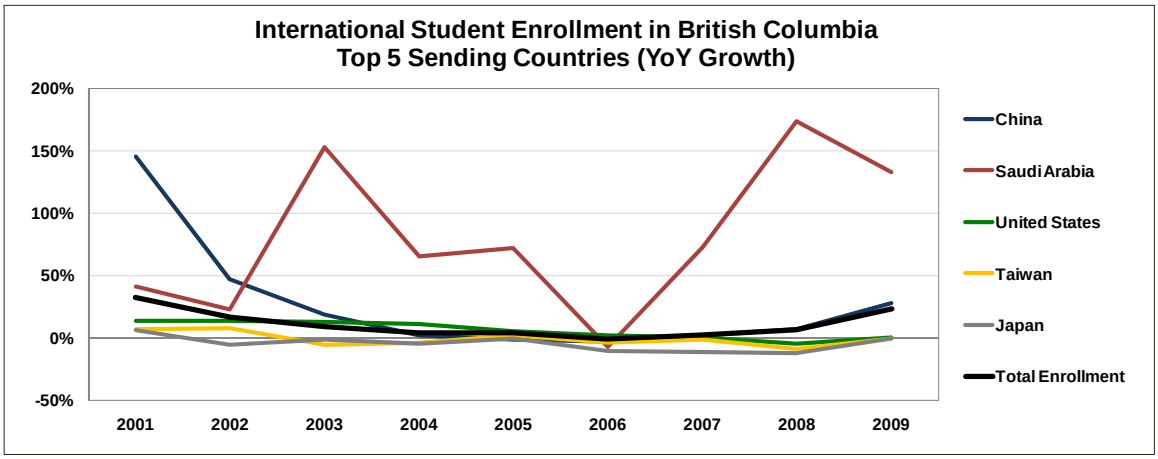
In 2009, Chinese students made up 35.7 percent of all international students in British Columbia (up from 14.9 percent in 2000), followed by students from Saudi Arabia (8.7 percent), the United States (8.4 percent), and Taiwan (4.1 percent).

With the exception of the year 2006 (-1.3 percent overall enrollment decline), British Columbia experienced varying, yet consistent growth in international

[2] Total international student enrollment data for British Columbia were sourced from Citizenship and Immigration Canada (CIC). CIC data encompass all international students present in British Columbia on 1 December of a given year. Data denote all international students in CIC's "University" and "Other Post-Secondary" education segments. Granular enrollment data were retrieved from Statistics Canada's Postsecondary Student Information System (PSIS), which collects detailed international student data from all Canadian colleges and universities via annual surveys. Survey participation is mandatory. Response rates hover around 80 percent.

student enrollments (see graph below). The 2009 overall enrollment growth of 23.6 percent was the highest since 2000 (32.2 percent).

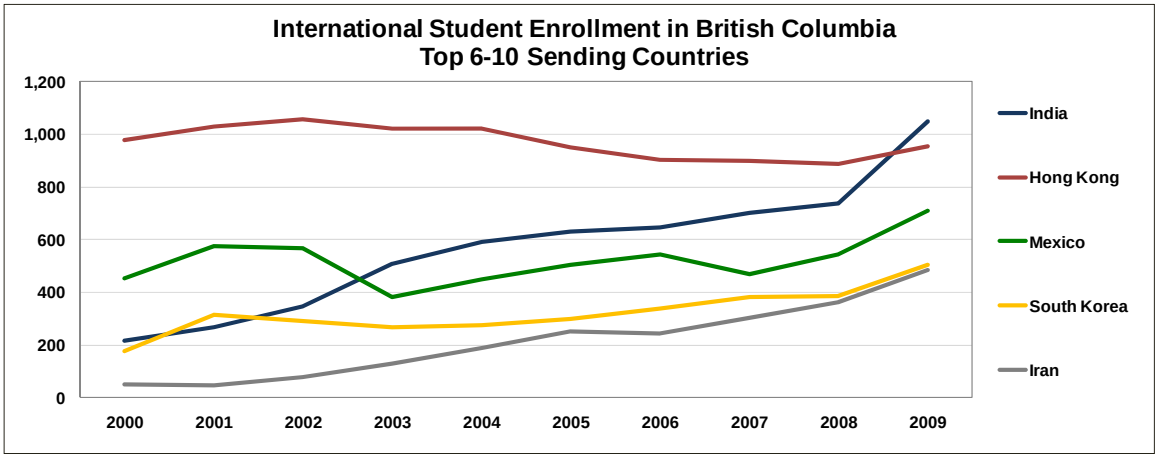
International Higher Education Student Enrollment in British Columbia by Top 5 Sending Countries (Year-over-Year Growth)



Notes: Data denote international students in CIC's "University" and "Other Post-Secondary" education segments.
Source: CIC.

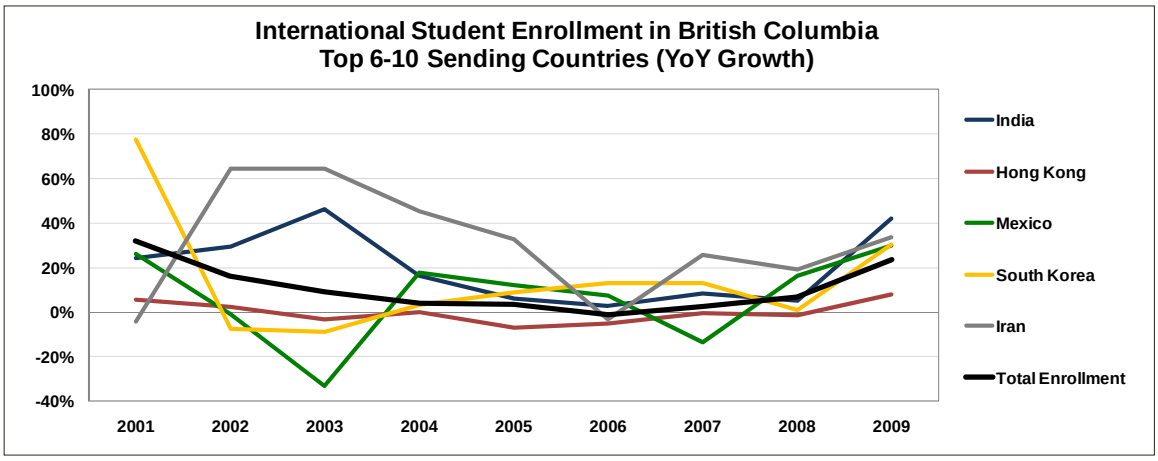
The 2009 overall enrollment growth was also reflected in the growth rates of the Province's Top 6 to 10 sending countries, India, Hong Kong, Mexico, South Korea, and Iran, whose enrollments grew between 7.8 and 42.2 percent in 2009.

International Higher Education Student Enrollment in British Columbia by Top 6-10 Sending Countries (Total)



Notes: Data denote international students in CIC's "University" and "Other Post-Secondary" education segments.
Source: CIC.

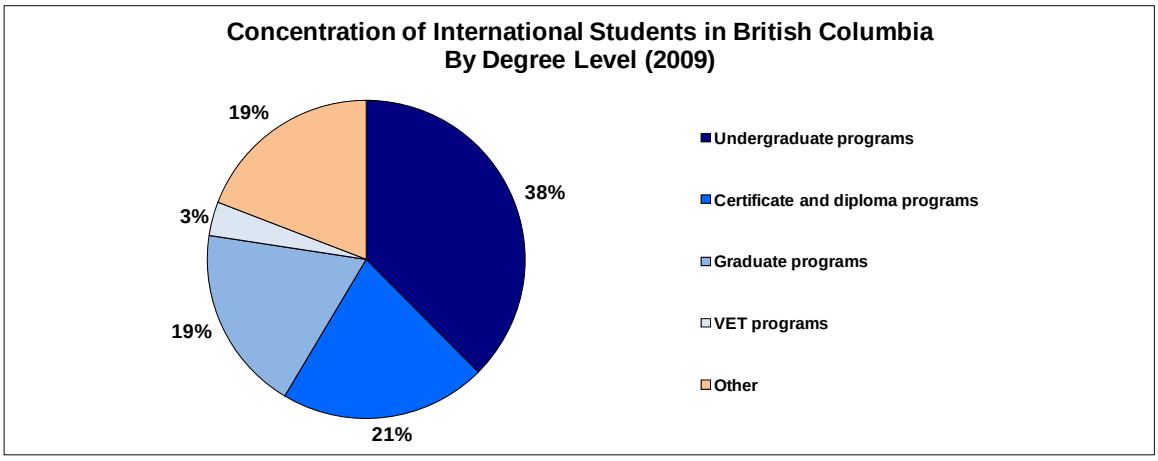
International Higher Education Student Enrollment in British Columbia by Top 6-10 Sending Countries (Year-over-Year Growth)



Notes: Data denote international students in CIC's "University" and "Other Post-Secondary" segments.
Source: CIC.

A granular assessment of enrollment trends in British Columbia revealed minor shifts in overall gender balance, from 53.3 percent female students in 2001 to near parity (50.8 percent female students) in 2009.[3] When split by degree level (see graph below), undergraduate programs (37.6 percent) represented the largest share of international enrollments, followed by certificate and diploma programs (21.0 percent), and graduate programs (18.9 percent).

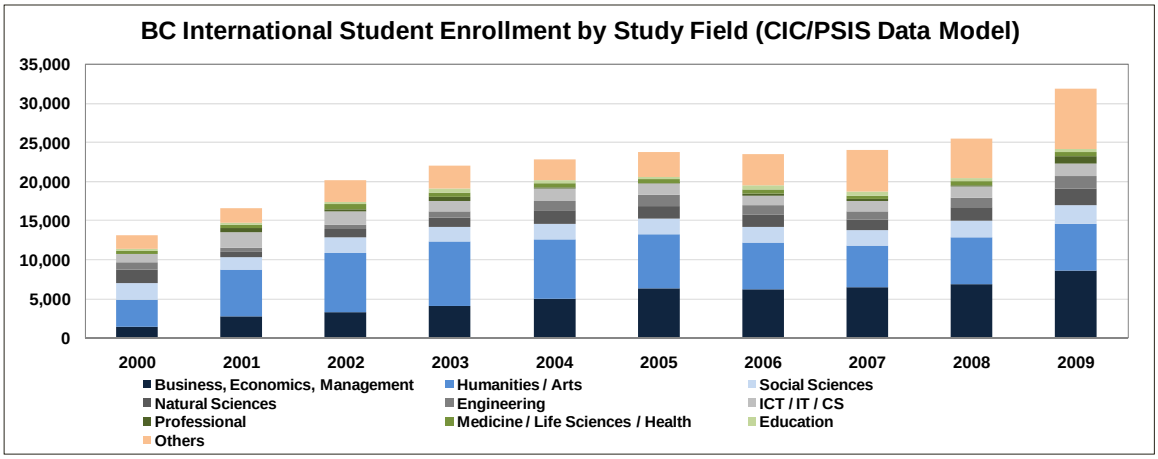
Concentration of International Students in British Columbia by Degree Level



Notes: Data encompass all international student enrollments reported by Canadian colleges and universities. PSIS data are collected through annual surveys. 2009 denotes the 2008/2009 academic year.
Source: PSIS

[3] Individual sending countries exhibited distinct distribution patterns: India (68 to 32 male-female balance), Japan (31to 69), and Saudi Arabia (90 to 10).

International Higher Education Student Enrollment in British Columbia by Study Field (Total)



Notes: Data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares by study field. PSIS data are collected through annual surveys covering more than 80 percent of Canadian colleges and universities. 2009 denotes the 2008/2009 academic year.
Sources: CIC, PSIS.

The above graph exhibits salient study field preferences expressed by international students in British Columbia. Underpinned by a consistent, near 50 percent combined share of enrollments in business and humanities programs, enrollment growth is largely driven by shifts in other study fields such as professional programs, whose enrollments increased more than six-fold between 2008 and 2009.

ON FORECASTING

General Comments, Methods, and Measurement Error

General Comments

Any reasonable forecast of complex, real world phenomena must take into account, in some capacity, the historic trends in the observed events. By regarding a given phenomenon – e.g. international student mobility in the case of ISAFM – as a variable in a statistical model, forecasters are able to assess the existence of historic trends or patterns in the said variable, as well as other variables which are assumed to influence changes in the observed phenomenon.

Looking forward to 2014, ICG's International Student Analytics and Forecasting Model (ISAFM) made use of a ten year "look back" period in collecting and analyzing data from 2000 to 2010. The look back period gained some leverage of understanding and estimating patterns within, and between, relevant variables. These observed patterns and relationships, in turn, enabled forward–looking predictions. Several statistical methods including time series, as well as linear, and multivariate regression techniques were used in analyzing the historic data.

The nature of the forecasting problem necessitated a thorough assessment of data which entail both cross-sectional (multiple country) and temporal (multiple year) dimensions. As a result, several panel data regression methods were utilized in both the 'look back' analysis and 'look forward' predictions.

To account for distinct demand and supply drivers modulating the flow of international students at multiple levels, ISAFM took a three-tiered approach to the modeling and forecasting problem:

- International student enrollment in Canada (first tier).
- International student enrollment in British Columbia (second tier).
- International student enrollment at individual institutions (third tier).

The first tier denotes the highest level of abstraction. By forecasting the likely trajectory for international student enrollments in Canada as a whole, ISAFM highlights salient overarching mobility trends which are partly reflected in the model's second and third tier predictions.

Forecasting Methods

Forecasting the flow of international students was approached from two angles:

- Modeling based on factors which “push” students to leave their home country and pursue higher education abroad.
- Modeling based on factors which "pull" students to study in a given destination country, province, or institution.

In order to increase confidence in projected enrollment trends ISAFM forecasts are based on multiple statistical modeling methods as well as multiple layers of data and validation checks. Forecasting methods include:

- ARIMA Time Series Models
- Bayesian Multivariate Dynamic Panel Regression Models
- Best Linear Unbiased Prediction Models (BLUP)
- Fixed Effects Regression Models
- Machine Learning Techniques
- Random Effects Regression Models with Time Effects
- Pooled Ordinary Least Squares Models
- System Dynamics
- Three Stage Least Squares Models (3SLS)

For more details on forecasting methods, please refer to ISAFM Modeling chapter.

Measurement Error

Measurement error denotes error or noise in the data at hand. In some instances, these disturbances can lead to less precise models which produce biased estimates and, potentially, biased forecasts.

Whether or not measurement error is a problem for the analysis depends heavily on the type of measurement error:

- Error on the dependent variable (here: international student mobility).
- Error on the independent variable(s).
- Error in the process.

In the context of ISAFM, international student mobility data denote the dependent variables, i.e. the variables which are forecasted by the model. All other variables which are used to produce the forecast denote independent variables.

The potential bias caused by all three types of measurement error depends on whether a measurement error in one variable is correlated with the other variables. If so, the estimates produced by the model will be biased. If the measurement error is not correlated with the other variables, the model's estimates are not biased. In the context of ISAFM, the mean of the error is not of primary importance as it only influences the estimates of the mean level of enrollments, but does not influence the estimate of the trend.

Prior to building the ISAFM core model, all 1.9 million data points were subjected to multiple quality and validation checks in order to detect errors in all datasets.

The treatment of measurement errors was guided by a consistent approach which included running models with and without the erroneous observations, as well as including forecasts from models that take into account measurement error and imputed data.

Past International Education Forecasts

IDP's 2025 Forecasts

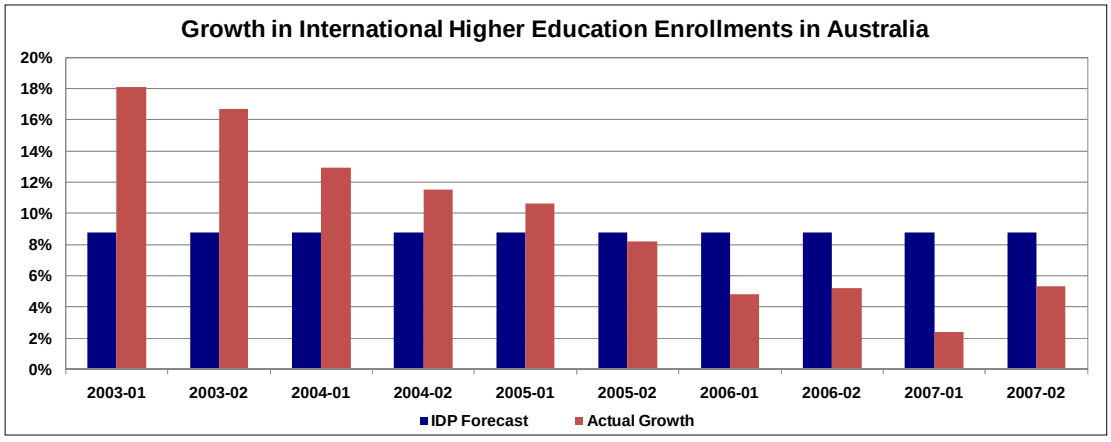
IDP Education Pty Ltd has published three forecasts of international student mobility:

- Global Student Mobility: An Australian Perspective Five Years On (2007)
- Global Student Mobility 2025 (2002)
- International Education: Australia's Potential Demand and Supply (1995)

Despite adjustments in data collection and forecasting methodology, all three reports operated with a steady-state growth model based on demographic projections, GDP per capita, tertiary participation ratios, and going abroad rates.

By using a 1999 to 2004 time series, the 2007 report sought to project international student enrollments 18 years out (2025). After overshooting in 2002, the 2007 report lowered growth assumptions to arrive at a total of 3.7 outbound mobile students – a number which was possibly surpassed in 2010.[4]

Growth in International Higher Education Enrollments in Australia (AEI Data vs. IDP Forecast)



Sources: AEI, IDP.

Similarly, IDP's average annual growth assumption renders IDP's short-term projections less useful for strategic decision-making. As shown in the graph

[4] The 2010 OECD Education at a Glance publication reported 3.34 million outbound mobile students in 2008. Comprehensive 2009 data on outbound mobile students are not yet available.

above, IDP's steady state growth rate of 8.8 percent deviated from actual enrollment growth by more than 100 percent.

Apart from official UN population predictions, forecast data for other independent variables such as GDP per capita were largely based on IDP expert assumptions and calculations. Despite their pivotal role in determining the supply pool of international students in the IDP model, official World Bank and IMF GDP per capita forecasts were not used in the model.

British Council's 2020 Forecasts

The British Council's 2004 report *Vision 2020 - Forecasting International Student Mobility* was a joint effort by the British Council and IDP to extend the IDP's *Global Student Mobility 2025* study.

The British Council's forecasting model denotes an appended version of the 2002 IDP model. In addition to the IDP forecast – which was largely based on demographic projections, GDP growth, and tertiary access ratios – the British Council employed a discrete choice model in order to forecast international student enrollment in competing English language destination countries.

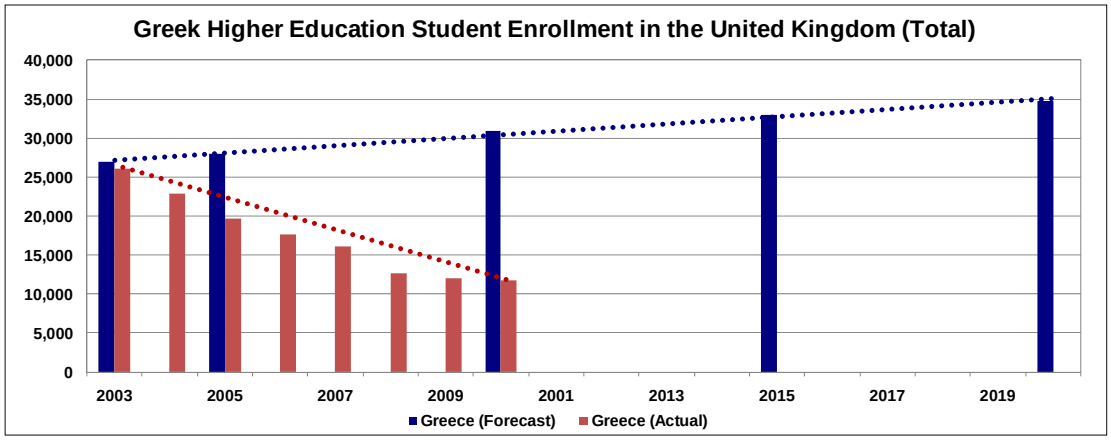
The discrete choice model assumed a total of five destination countries: Australia, Canada, New Zealand, the United Kingdom and the United States. Other key destination countries such as Germany, France and (by now) China were not considered. The variables utilized in the statistical model encompassed subjective attractiveness ratings which were developed by the British Council, IDP, and representatives of the UK's international education industry.

The British Council utilized scenarios (base, optimistic, pessimistic, etc.) by manually adjusting destination countries' market shares which were assumed constant in the base scenario. Similar to the variables of the discrete choice model, market share adjustments were based on expert opinions, not hard data.

Granular forecasts for international students by degree level and study field were based on the model's overall forecast and shares observed in historical data.

Operating on IDP's basic forecasting model, the British Council's model projected a similar growth trajectory, forecasting consistent growth until 2020.

Greek Higher Education Student Enrollment in the United Kingdom (HESA Data vs. British Council Forecast)



Sources: British Council, HESA.

Similar to the IDP report, the British Council's choice of variables and their interdependency resulted in inaccurate forecasts for a number of countries. As shown in the above graph, the British Council forecast for Greek student enrollments in the United Kingdom featured strong deviations in both its short and long run projections.

In 2008, the British Council launched a second large scale international student forecasting project, which was jointly executed with the Economic Intelligence Unit. Information on forecast results and methodology are not publicly available.

While the overall direction of the IDP and British Council forecasts – notable international student enrollment growth – has proven accurate, this instance can largely be attributed to common wisdom, overall ecosystem dynamics, and a short observation period.

IDP and the British Council undertook valuable, early pioneer work in the field of international student enrollment forecasting. However, data, methods, and overall methodology were not suited to produce reliable of inherently accurate forecasts.

Unlike the IDP and British Council models, ISAFM's analytical rigor is rooted in its political independence. As a consequence, ISAFM does not assume prior trends such as the unfettered growth in international student enrollments.

INTRODUCTION TO ISAFM

Vision

The core vision driving ISAFM is to create an integrated analysis and forecasting model which allows for the concise, systematic, and evidence-based modeling of international student mobility dynamics at a national, state/provincial, as well as at an institutional level.

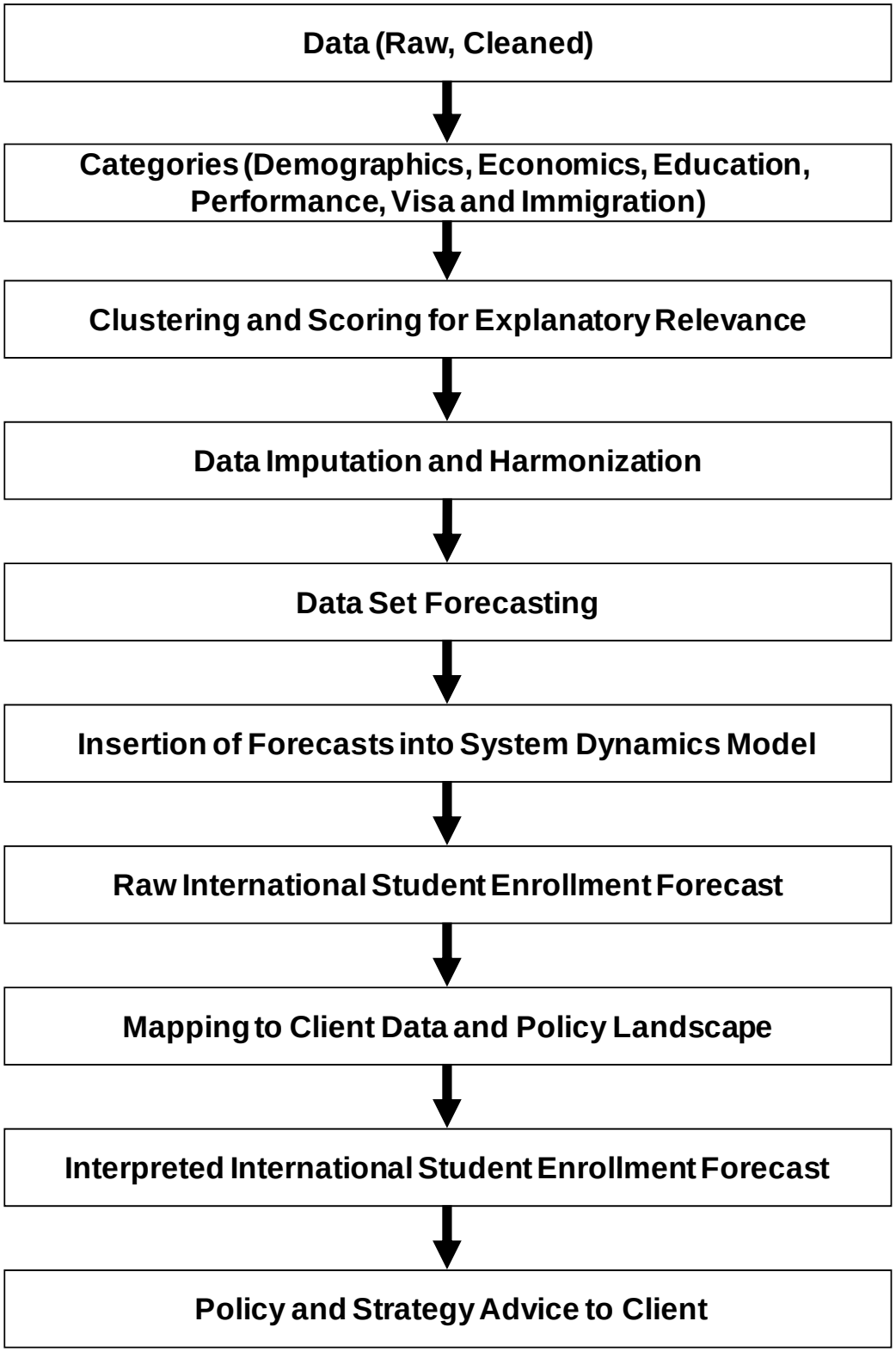
This vision was shaped by the wide-spread absence of expert analytics in international education competition analysis and strategy development.

ISAFM's intended usage and client service center on:

- Its role as a strategic enabler – ISAFM facilitates an evidence-based understanding of population, market, competition, and performance metrics at an in-depth, unbiased level.
- Its function as a student recruitment support mechanism – ISAFM augments, adds, corrects, and supplements a client's knowledge base, and assists with resetting policies and practices.
- Its ability to operate with in-depth client data (through mapping) to focus on immigration, talent segments, or target markets, at a granular level.
- Its focus on an actionable time horizon – ISAFM operates with rolling twelve months "current data" and 36 months "forecast data" timelines.

ISAFM is being offered as an integrated policy and strategy development model rather than as a data and forecasting service. Given the complexities inherent in ISAFM, the latter would pose substantial challenges in terms of clients' ability to interpret and apply the results of ISAFM's analysis forecasts.

ISAFM Model High Level Overview (Schematic)



Scenarios

Introduction to Scenarios

System Dynamics-based Scenarios are based on a defined set of events already or potentially impacting international student flows. While, in theory, the definition of scenarios can be broad and amorphous, in practice scenarios are tightly defined to allow for a modeling of impact factors.

Scenarios allow adjustments for real-life variations to the baseline ISAFM forecast. Scenarios can cover existing and/or emerging events, or reflect on the likely impact of hypothetical events. In this sense, Scenarios can act as concise forecast models for the impact of policy and strategy adjustment..

Examples of Scenarios

- Economics Crisis Scenario: This scenario focuses on the at times counter-intuitive and distinct responses to economic crisis situations. The scenario focuses on short-term impact dynamics. Past economic crisis examples include the Asian currency crisis of 1997-98, and the global financial and economic crisis of 2007-09.
- Pandemic Scenario: This scenario focuses on the impact of pandemics on the travel and mobility patterns of students. Past pandemic examples include SARS and H1N1.
- Policy Conflict Scenario: Policy conflict scenarios center on specific, public, and meaningful policy conflicts which alter, disrupt, or fundamentally change international student flows. Examples include the India-Australia student security situation of 2009-10, or the change in visa and immigration policies by the US Government following 9/11.
- Competition Scenarios: These scenarios encompass a wide array of factors, ranging from policy changes to promotion activities, to changes in the perception of countries. Examples include notable changes in national promotion spending, the introduction or changes in tuition fee levels (Germany 2006, Sweden 2010), or a change in the attractiveness of a country (USA post 9/11).
- Regulatory Scenarios: This scenario reflects on existing conditions and/or changes in key admissions, visa, and immigration regulations. Given their categorical and/or cut-off nature, regulatory scenarios are closely tied into competition scenarios. Examples include visa application category reclassifications of applicants from a given country, or changes in the nexus between education and immigration.

General Limitations

ISAFM is characterized by a number of limitations, some of which are outside the control of ICG. Additional in-depth comments are contained in the ISAFM Data chapter.

First order limitations include:

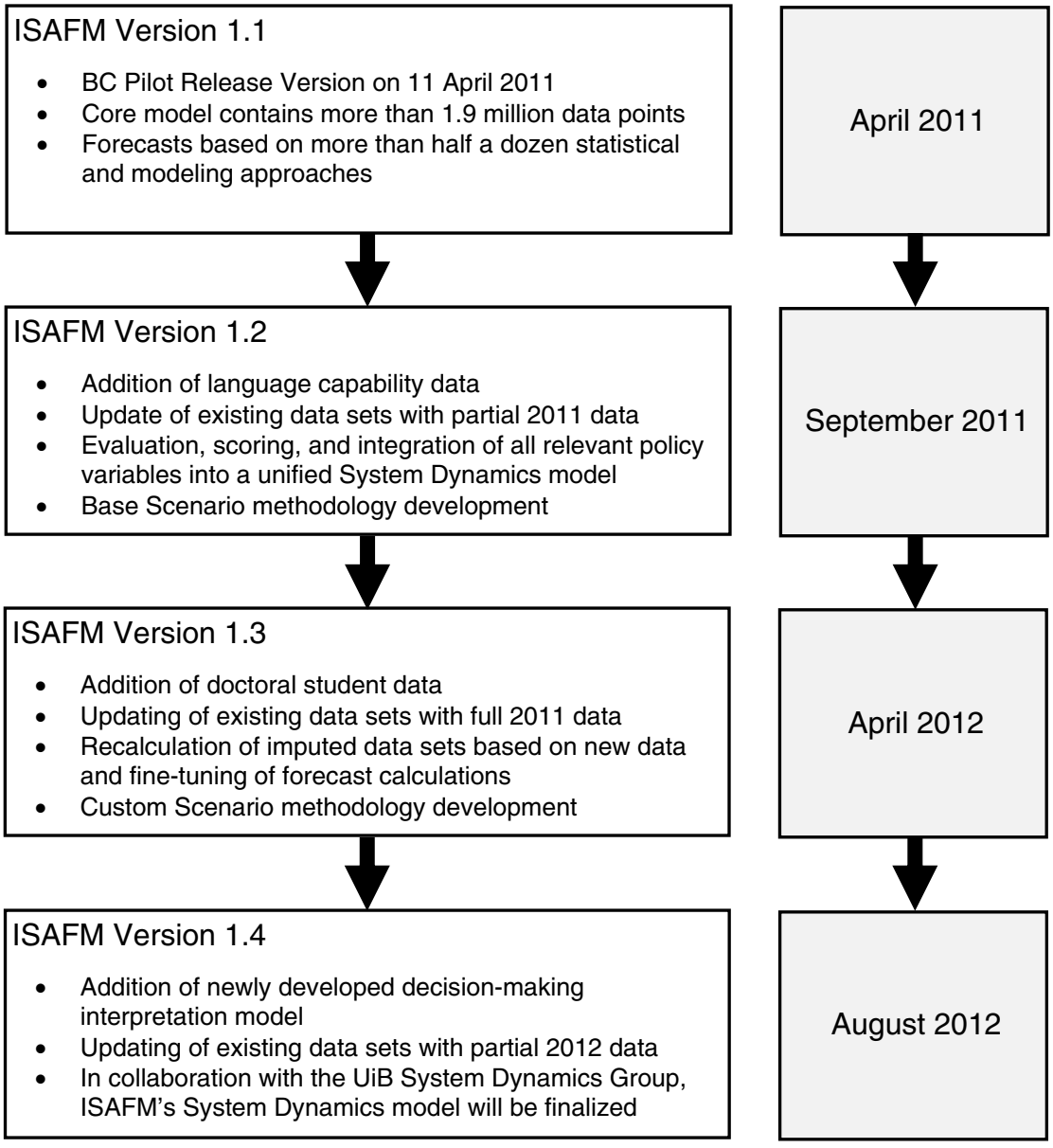
- A complete or substantial lack of data. This situation occurs when the owners of data do not make such data publicly available, or if data have never been collected, or if no time series data exist.
- Incorrect, incomplete, or mis-specified data. Instances of incorrect data are surprisingly common and often reflect transcription or computation errors while mis-specified data reflect changes in classification and attribute definition.
- Measurement unit (definition of "one" international student). A key limitation is that ISAFM has to rely on reported statistics which in the case of international student enrollment are subject to an unusually broad range of measurement definition (which in this case numerically equates a Chinese scholarship PH.D. student enrolled in a Canadian university with a U.S. undergraduate summer abroad student in Spain).

Second order limitations include:

- Gaps in data sets. A fairly common occurrence is missing years or missing sub-variables. This is especially (and naturally) the case if data reflect on surveys which are not run on an annual basis (such as PISA).
- Characterization and scoring of data. As part of ISAFM's statistical modeling, data were scored on a number of proprietary scales. Scoring data for their likely impact on student behavior or economic impact is not a precise science, but one based on experience and categorical judgments.
- Predictive power and reliability of statistical and forecasting models. This limitation is commented on in the ISAFM Modeling chapter.

ISAFM Development Stage and Future Development Directions

ISAFM as an integrated analytical service has been developed since the fall of 2009. The current release version (1.1) contains all structural and forecast properties of subsequent planned release versions. Later versions will incorporate additional and/or more in-depth data categories, and roll up additional explanatory variables into a unified System Dynamics model. At the same time, imputed data will be replaced and or adjusted based on new data having become available.



ISAFM DATA

Data Categories

ISAFM's underlying data model is built on more than 1.9 million data points. Data collection focused on 64 key countries (see Appendix for detailed list) starting in the year 2000. Data are organized into five major categories:

- Demographic data
- Economic data
- Education data
- Performance
- Visa and immigration data

Demographic Data

Demographic data provide information about long-term trends in underlying population sizes which broadly condition overall education demand patterns.

Economic Data

Economic data provide an important modifier with regards to demographic demand patterns at categorical as well as minute impact levels.

Education Data

Education system and institution data provide a detailed (demand and/or supply) baseline of past and current participation as well as resource levels.

Performance Data

Performance data provide relevant context and segments both for sending as well as receiving countries with the aim to introduce a quality hierarchy.

Visa and Immigration Data

Visa and immigration data reflect clear and specific conditions for obtaining information, applying, and processing a visa, border entry, and immigration options.

Variables

ISAFM's underlying data model comprises 129 variables with distinct explanatory power. The following selection of key variables is organized into ISAFM's five major data categories.

Demographic Variables

Demographic variables include (selection listed):

- Population by Age
- Population by Gender

Economic Variables

Economic variables include (selection listed):

- Disposable income
- Foreign exchange rates
- Gross domestic product (total, per capita, growth)
- Inflation rates
- Labor force (total, participation rates, educational attainment)
- Unemployment rates (total, educational attainment)

Education Variables

Education system variables include (selection listed, split between domestic and international students where applicable/available):

- Expenditures on education
- Expenditures on research and development
- Higher education enrollment (undergraduate, graduate)
- Tertiary enrollment
- Upper secondary enrollment
- Upper secondary completion
- Tuition fees

For higher education enrollment, the ISAFM data model includes country-specific data at a granular level. In the case of international student

enrollment, national data were retrieved for individual sending countries broken down by the following attributes:

- Total international student enrollment
- Enrollment by gender
- Enrollment by degree level (undergraduate, graduate)
- Enrollment by study field
- Any combination of the above

Depending on data availability, the ISAFM data model includes international student data at a high level of detail, e.g. the number of female Chinese undergraduate business students in a country in the year 2009.

The ISAFM data model utilizes a harmonized list of eleven internationally comparable study fields which were derived from international benchmark research (see Appendix for a complete list).

Performance Variables

Performance variables include (selection listed):

- Academic rankings (ARWU, QS, etc.)
- IELTS scores
- Nation brand indices
- PISA results
- Patents granted
- Survey data

Visa and Immigration Variables

Visa and immigration variables include (selection listed):

- Visa information acquisition
- Application processing (timeline, outcome)
- Visa decision (approval and decline rates)
- Border entry (success, experiences)
- Immigration (1) (options, timeline)
- Immigration (2) (residence, permanent)

Attributes

Data Sources

ISAFM draws on four principal data source categories:

1) Publicly available data from international organizations. Examples include the IMF, European Commission, OECD, World Bank, and UNESCO (UIS).
2) Publicly available data from national organizations. Examples include the national statistical offices, national ministries of education, and national ministries of commerce or economics.
3) Commercially available data from private corporations. Examples include the Economist (EIU), Pew Research and Oanda.
4) Specific client data. Client data are only used in client projects and reside outside of the core data model.

Client data were handled separately from the ISAFM core model. Client data confidentiality was safeguarded through a number of measures, including restricted access rules.

Data Timeline

ISAFM operates with three, sliding timelines:

- Historical data. This data timeline commences in January 2000 and stretches until December 2010.
- Current data. This timeline ranges from January 2011 to December 2011.
- Forecasted data. This timeline ranges from January 2012 to December 2014.

The above timelines are subject to a forward moving slide function. Depending on the structure and nature of data, the current and forecasted timelines are moved every three to six months.

Data Depth

Data were retrieved for 162 countries, with a particular focus on 64 key sending and receiving countries of international students (see Appendix). Data depth ranges from daily to annual data.

All data were collected in the ISAFM Data Matrix, an excerpt of which is shown in the image below. The Data Matrix allows for the input of granular, country-specific data for a 2000 to 2020 time series, with ISAFM data sets reaching up to 31 December 2010 at the time of the pilot release.

ISAFM Data Matrix: International Student Enrollment in Canada (Total)

	2000	2001	...	2007	2008	2009	2010
Afghanistan	0	0	...	0	9	17	n/a
Albania	15	19	...	34	47	59	n/a
Algeria	92	92	...	239	330	381	n/a
Angola	0	6	...	0	39	39	n/a
Argentina	174	177	...	118	115	121	n/a
Armenia	0	0	...	0	0	0	n/a
Australia	454	537	...	384	349	326	n/a
Austria	105	122	...	148	143	164	n/a
Azerbaijan	0	0	...	8	13	21	n/a
Bahamas	228	267	...	353	347	289	n/a
Bahrain	89	112	...	143	132	138	n/a
Bangladesh	452	712	...	1,306	1,358	1,418	n/a
Barbados	212	242	...	237	231	227	n/a
Belarus	21	17	...	34	31	33	n/a
Belgium	250	268	...	219	211	229	n/a
Benin	162	172	...	159	156	210	n/a
Bermuda	384	468	...	560	515	501	n/a
Bolivia	19	26	...	24	27	36	n/a
Bosnia and Herzegovina	0	0	...	11	14	15	n/a
Botswana	136	158	...	255	303	302	n/a
Brazil	537	607	...	680	778	936	n/a
...	...	...	...	...	...	...	n/a
Uganda	85	112	...	128	137	156	n/a
Ukraine	202	220	...	216	223	292	n/a
United Arab Emirates	578	773	...	1,306	1,391	1,491	n/a
United Kingdom	1,050	1,097	...	1,240	1,237	1,343	n/a
United Republic of Tanzania	166	203	...	225	231	257	n/a
United States	6,344	7,160	...	9,819	9,466	9,504	n/a
Uruguay	15	10	...	27	24	33	n/a
Uzbekistan	7	8	...	8	6	8	n/a
Venezuela	325	488	...	464	417	495	n/a
Viet Nam	321	375	...	837	903	1,100	n/a
Yemen	33	42	...	137	130	142	n/a
Zambia	45	54	...	210	230	238	n/a
Zimbabwe	79	96	...	173	182	229	n/a
Totals	**62,229**	**76,363**	...	**112,043**	**116,278**	**134,564**	**n/a**

Notes: Data denote international students in CIC's "University" and "Other Post-Secondary" education segments. Full table includes 162 countries. Displayed table was shortened due to size constraints.
Source: CIC.

Quality

All data in the ISAFM data model were retrieved, reviewed, cleaned, and imported in a highly standardized format. Whenever available, national data were obtained to append and overwrite international data.

All data acquisition efforts were led by a comprehensive set of documentation requirements: Raw data, source information, and data definitions were obtained in order to facilitate future data acquisition, and to ensure comparability across multiple sources. Whenever necessary, the ISAFM research team followed up with the owner of the data to obtain direct validation on data definitions, publication schedules, and the availability of additional data.

For the dependent variable, international student enrollment, granular data were obtained from national sources. Whenever available, international student enrollment data were retrieved for each sending country broken down by the following attributes:

- Total international student enrollment
- Enrollment by gender
- Enrollment by degree level (i.e. undergraduate vs. graduate)
- Enrollment by study field
- Any combination of the above

Depending on data availability, the ISAFM Data Matrix is capable of storing international student data at a high level of detail (see below).

ISAFM Data Matrix: Female Chinese Undergraduate Students in Canada

Country	Level	Gender	Study Field	2000	2001	2002	...	2008	2009	2010
China	UG	Female	Law				...			
China	UG	Female	Business, Econ., Management	276	546	1,041	...	3,387	3,684	n/a
China	UG	Female	ICT / IT / CS	99	249	441	...	573	564	n/a
China	UG	Female	Medicine / Life Sciences / Health	6	9	36	...	87	84	n/a
China	UG	Female	Education	3	0	3	...	3	3	n/a
China	UG	Female	Natural Sciences	39	78	120	...	447	453	n/a
China	UG	Female	Social Sciences	87	189	243	...	1,197	1,065	n/a
China	UG	Female	Humanities / Arts	93	138	261	...	735	822	n/a
China	UG	Female	Engineering	36	69	132	...	261	255	n/a
China	UG	Female	Professional	0	0	0	...	0	3	n/a
China	UG	Female	Others	48	54	63	...	165	183	n/a
China	**Subtotal**			**684**	**1,335**	**2,331**	...	**6,852**	**7,110**	**n/a**

Notes: Data encompass all international student enrollments reported by Canadian colleges and universities. PSIS data are collected through annual surveys. 2009 denotes the 2008/2009 academic year.
Source: PSIS

Notable Gaps

Global Data

Global data were retrieved from both international organizations and national sources. Data availability was subject to three types of gaps:

- Missing years
- Missing country data
- Variable-specific gaps

Missing Years

Depending on individual datasets and their underlying data collection and tabulation methods, a full 2000 to 2009 time series could not be obtained for all variables in the ISAFM data model. With publication schedules of international education data lagging two years behind, 2009 and 2010 UNESCO data were not available for most education variables. Whenever available, existing gaps were filled with national data.

Missing Country Data

The completeness of most time series data published by international organizations is contingent on the data submission of individual member countries. Due to countries' diverging capabilities to collect comprehensive data, a number of international datasets featured incomplete data for relevant countries. At times, these gaps were rooted in membership issues (e.g. Taiwan was not featured in any UNESCO dataset). Whenever available, existing gaps were filled with national data.

In addition, the absence of country data was partly rooted in selective publishing practices. For example, a number of performance variables such as English language test scores by country were only published for the countries with the highest number of test takers.

Variable-Specific Gaps

Variable-specific gaps are a result of distinct properties of individual variables in the ISAFM data model. Demographic and economic data were largely complete due to their central role in national data collection

efforts. Other, less prominent variables such as entry ratios for tertiary education and visa approval rates featured comparatively more gaps.

Missing data were not always rooted in collection and tabulation efforts. For select variables such as academic rankings and survey data, historical data did not date back to 2000.

Canada Data

Canada data were retrieved from international, national, and provincial sources.

International organization data on Canada were largely complete. Existing gaps and underestimations for select education metrics, including international student enrollment, were overwritten with national data.

In the case of international student enrollment data, UNESCO and OECD data were replaced with Citizenship and Immigration Canada (CIC) data. In addition, more granular international student data (i.e. by gender, degree level, and study field) were purchased from Statistics Canada's Post-Secondary Information System (PSIS).[5]

Nation-wide higher education admissions data (i.e. applications, offers, entries, etc.) were not available. Neither were study and immigration pathways data, which would allow for an in-depth analysis of post-entry dynamics of both domestic and international students.

Understanding the flow of students beyond their entry into Canada's numerous education sectors allows for strategic adjustments to future student recruitment and retention efforts.

British Columbia Data

British Columbia data were retrieved from both provincial and national sources.

Available data on British Columbia were largely complete. International student enrollment data for British Columbia were retrieved from CIC. In

[5] CIC data encompass all international students present in Canada on 1 December of a given year. Data denote all international students in CIC's "University" and "Other Post-Secondary" education segments. PSIS collects detailed international student data from all Canadian colleges and universities via annual surveys. Survey participation is mandatory. Response rates hover around 80 percent.

addition, more granular international student data (i.e. by gender, degree level, and study field) were purchased from PSIS.

Comprehensive province-wide higher education admissions data were not available. No surveys on potential students' perception of the attractiveness of British Columbia as a study destination were available.

Dealing with Data Gaps

Missing data were handled through data imputation which was performed in a Bayesian framework.

Methods for data imputation range from simple random imputation which involves imputing missing values from observed values, to deterministic or random regression imputation which involves using regression predicted values for a variable to fill existing gaps in the dataset.

In the case of ISAFM, the missing data problem was handled with regression techniques within a Bayesian framework. Bayesian statistical analysis is based on the Bayes' Theorem, which explicates a way to update prior beliefs about some object of interest – for example, a regression parameter, in light of available data, to yield posterior beliefs.[6] With the virtually unbounded computing power available today, simulation based on the Markov Chain Monte Carlo (MCMC) principle, makes Bayesian analysis a very powerful technique for statistical inference.

The missing data in the ISAFM analysis was modeled using a random walk regression process. Graphical inspection of the key variables leant support to the hypothesis that the dynamic nature of the data was such that at each time period, the current value of the variable in question was similar to the previous value of the variable, plus or minus random and minor perturbations.

More formally, the current value of a random variable is equal to the previous time period value plus an error term which is assumed to be white noise. This implies that the best prediction for the one step ahead future value of a random variable is the current value. For the ISAFM analysis, vague, uninformative, but proper priors are defined, letting observed data drive the inference process.

[6] This methods centers on the principle that "Anything we want to know about a random variable (x), we can learn by sampling from g(x), the probability density function of x." (Jackman, 2000).

ISAFM MODELING

The Purpose of Forecasting

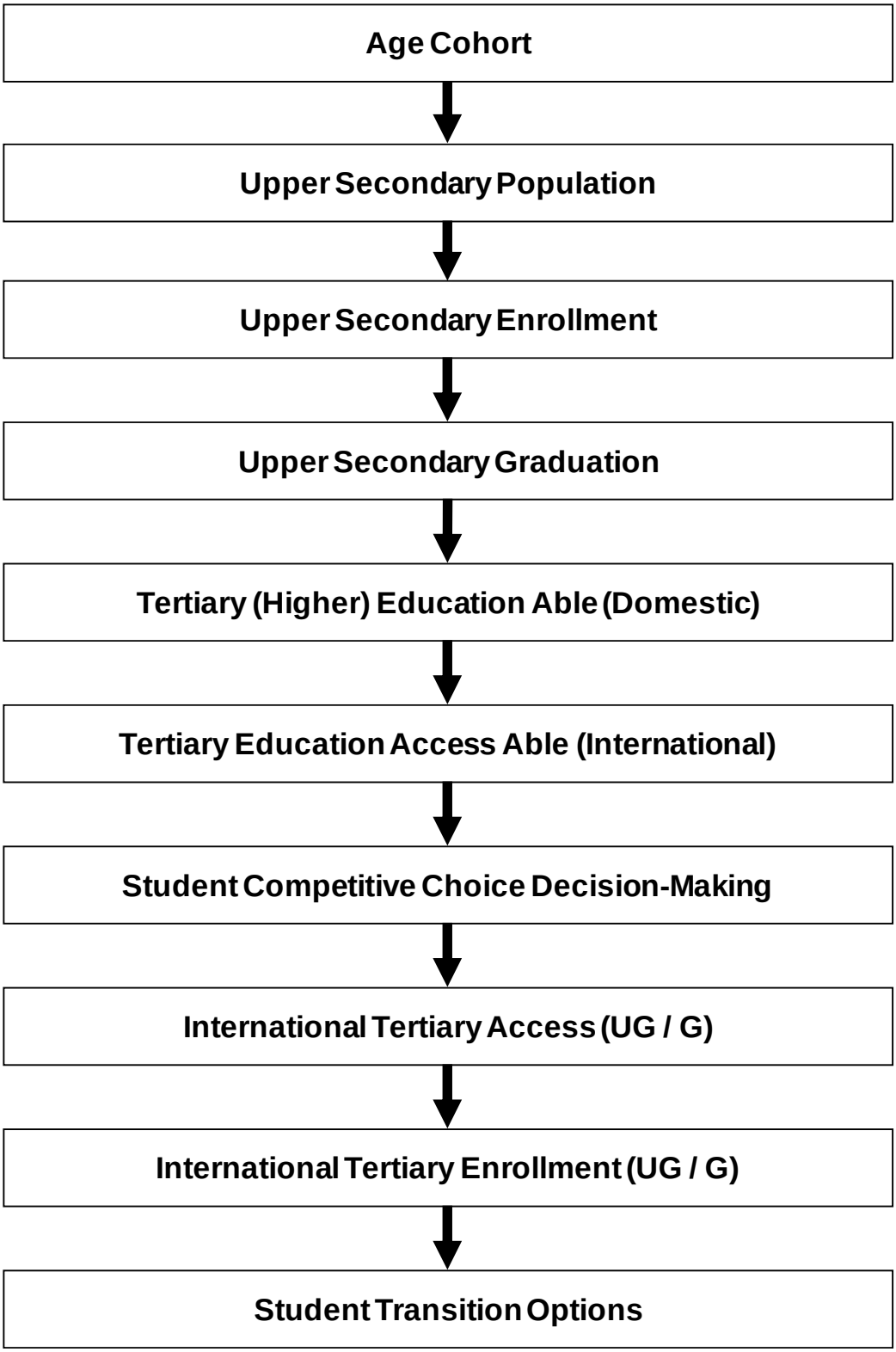
Forecasting international student enrollments is not fanciful entertainment or an end unto itself. It is an increasingly critical component of marketing, recruiting, and general competition management activities undertaken by countries, states and provinces, and institutions alike.

Proper forecasting provides critical perspectives on the interaction of supply and demand patterns, competition levels, students' sensitivities to changing conditions, and the best application of resources.

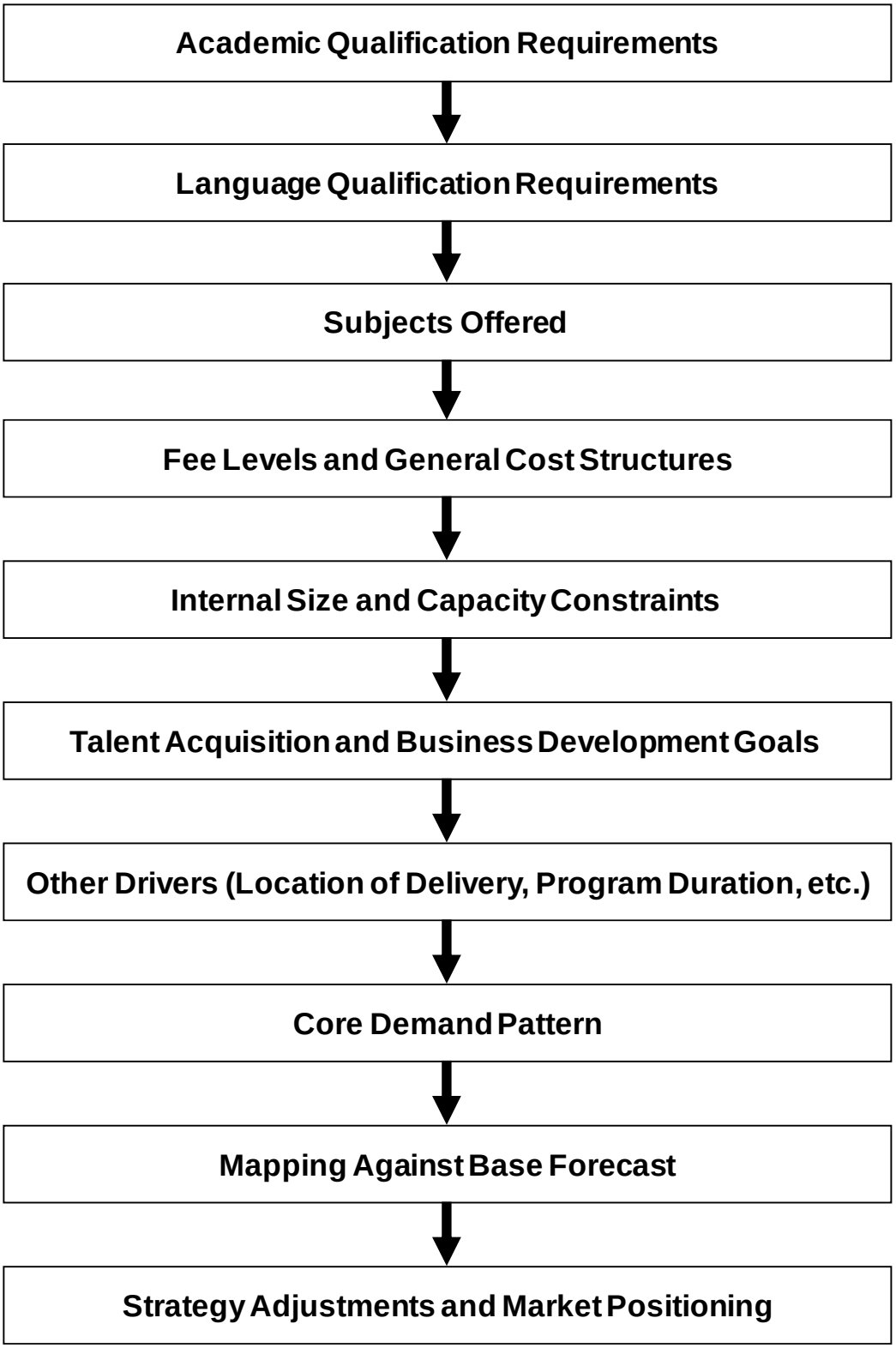
Without forecasting, activities are bound to rely on estimates, guesses, or operate wholly without any forward-looking information. Not only does this entail a high degree of potential error, such an approach also does not allow for a rational, comprehensive manner of operation.

Forecasting thus holds one essential national, provincial, or institutional purpose: Better information leads to better decision-making which leads to a competitive advantage.

Student Flow Model (High Level Schematic)



National/Provincial/Institutional Demand Model (High Level Version)



Statistical Methods

In order to forecast the flow of international students into Canada, British Columbia and select higher education institutions, the International Student Analytics and Forecasting Model explored a total of 15 statistical modeling methods:

- ARIMA Time Series Models
- ARMAX Times Series Models
- Bayesian Multivariate Dynamic Panel Regression Models
- Best Linear Unbiased Prediction Models (BLUP)
- Between Effects Regression Models
- Discrete Choice Models
- Fixed Effects Regression Models
- Fixed Effects Regression Models with AR(1)
- Feasible Generalized Least Squares Models
- Machine Learning Techniques
- Random Effects Regression Models with Time Effects
- Random Effects Regression Models with AR(1)
- Pooled Ordinary Least Squares Models
- System Dynamics
- Three Stage Least Squares Models (3SLS)

Upon validation, the following nine statistical modeling methods were used to generate the ISAFM Forecasts:

- ARIMA Time Series Models
- Bayesian Multivariate Dynamic Panel Regression Models
- Best Linear Unbiased Prediction Models (BLUP)
- Fixed Effects Regression Models
- Machine Learning Techniques
- Random Effects Regression Models with Time Effects
- Pooled Ordinary Least Squares Models
- System Dynamics
- Three Stage Least Squares Models (3SLS)

Autoregressive Integrated Moving Average (ARIMA) Time Series Model

Time Series Models are used to explain the evolution of a variable or process that varies with time. Time Series Models denote one of the classic forecasting techniques.

Time Series Models require that the observed process be relatively stable, meaning the average and variability of the process are not subject to significant changes with time. Time Series Models use the historic average, volatility, and trends of the process to predict the future path of the process.

Explanatory variables are not needed to fit a time series (although there are Time Series Models which use independent variables). Instead, historic trends are used to forecast the future path of the variable.

Before running any Time Series Models, unit root tests and correlation tests (between enrollment and previous years' enrollments) were employed to assess both the stability of the time series of enrollments and the predicative power of lag variables.

ISAFM fit a series of Autoregressive Integrated Moving Average (ARIMA) Models which use historic enrollments trends to predict the future path of enrollments. The ARIMA (1,1,0) Model yielded the best fit based on the predictive power of the previous years' enrollments. In addition, the difference transformation was employed to smooth out the non-linear trend in the data (i.e. slow enrollment growth in the 2003 to 2007 period).

Limitations to using Time Series Model include:

- The reliance on the dependent variable to generate forecasts requires steady and predictable growth patterns of past data.
- Time series models assume that all independent variables that explain enrollments will continue to grow predictably at the same rate and so they are not needed for analysis. If international student enrollments from a given sending country are significantly influenced by select external factors which change in an unpredictable way, Time Series Models generate suboptimal results.
- Time Series Models use only a few data points to forecast. As is the case with any model, only limited inference can be made with few data points.

The ISAFM Time Series Model could be improved with many more years of data. Time Series Models are frequently used to model financial processes that draw upon daily data. Given the annual or biannual nature of enrollment data, forecasts should not rely on Time Series Models alone.

Bayesian Forecasting

Bayesian statistical analysis is rooted in the Bayes' Theorem, which explicates a way to update prior beliefs about some object of interest – a parameter, a data point, a hypothesis – in light of some data, to yield posterior beliefs. The mechanics of Bayesian inductive learning are summarized by the principle that the posterior belief is proportional to the prior belief times the likelihood, where the likelihood is a function describing how likely the value of the parameter, value of the data point, or the hypothesis being tested, is, given the data.

The category of statistical models used in the ISAFM Forecast fall under the rubric of Bayesian Multivariate Dynamic Panel Regression Models. These Models' multivariate structure is appropriate because multiple variables are assumed to be correlated with the dependent variable, international student enrollment.

Two types of models were considered: Push models and pull models. Push models were aimed at forecasting the total international student enrollment trends in Canada, BC and individual institutions, from individual sending countries. These models were based largely on factors specific to the sending countries; i.e. factors that would *push* a student to enroll at a Canadian institution of higher education. Individual sending country forecasts were aggregated up to total numbers for Canada and British Columbia. Institutional forecasts were based on three year averages of British Columbia enrollment shares held by individual institutions.

Pull models were aimed at forecasting, in a global competitive environment, the total number of international student enrollments in individual receiving countries, considering Canada and its major competitors. These models were based largely on factors specific to the receiving countries, factors that would *pull* a student to that particular country.

The forecasts itself were derived using the ten year look back period to estimate the relationships between key explanatory variables and the levels of international student enrollment. Once these relationships had been estimated, forward predictions were based on these historically determined relationships.

Given the availability of more data, additional models could be estimated with potentially stronger predictive power. The current Bayesian Models do not account for any potential exogenous shocks that may affect global trend in international student mobility.

Best Linear Unbiased Prediction (BLUP) in a Panel Data Model

The Best Linear Unbiased Estimator (BLUP) Models produce forecasts with the smallest amount of uncertainty about the prediction. One key cost of this procedure is the reduction of precision in the point forecasts.

The data used in the ISAFM BLUP Model comprise the Top 20 sending countries to Canada and British Columbia and include demographic, economic, education, performance, and visa and immigration variables (see previous section on the ISAFM data model).

The BLUP Model assumes that enrollments are determined by push factors in select sending countries, including per capita income, population in the higher education age bracket, and domestic accessibility to higher education that would lead students to pursue an international education. In addition, pull factors like the affordability of Canadian universities and Canadian visa approval rates were taken into consideration. After estimating the historic relationship between salient push and pull factors and international student enrollments, the BLUP Model predicted future enrollments based on the trends and momentum in these factors.

Independent variables used in the BLUP model included:

- Population, age 20 to 24
- Number of outbound mobile students
- Canadian student visa approval rates (country-specific)
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita
- Daily foreign exchange rates with the Canadian Dollar
- Volatility of daily foreign exchange rates with the Canadian Dollar

Given the high computation complexity of BLUP Models, parameter estimates showed large variability in forecasts depending upon what input variables were included. The ISAFM BLUP Models could be improved by additional observations for each variable, e.g. a 30 year time series for each variable would provide more consistent and reliable forecasts.

Pooled Ordinary Least Squares Regression Models

The Ordinary Least Squares Model (OLS) denotes the most simple and parsimonious model to be employed using panel data. The model estimates a linear relationship between international student enrollments and the independent variables. It predicts future enrollment based upon this estimated relationship and trends in the independent variables.

Assuming no differences between countries or over time in how international student enrollments depend upon the independent variables, Pooled OLS Models allow for pooling all data points together, rather than delineating the data into a panel of country-year variable combinations.

Similar to the BLUP Model, the ISAFM OLS Model forecasted enrollment levels for Canada's and British Columbia's Top 20 sending countries. After stress testing for collinear variables and statistical robustness, the best OLS Forecast was generated upon inclusion of the following independent variables:

- Population, age 20 to 24
- Number of outbound mobile students
- Canadian student visa approval rates (country-specific)
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita
- Daily foreign exchange rates with the Canadian Dollar
- Volatility of daily foreign exchange rates with the Canadian Dollar

By applying the same push and pull country logic as in the BLUP Model, the OLS Model captured the changing dynamics of large sending countries and compensated for the "no differences between countries" assumption by placing more weight on the relationships between the changing dynamics of the independent variables above and international student enrollment.

The OLS Model explained 89% of the variation in international student enrollments using the independent variables above. The most important determinants of international student enrollments in this model were outbound mobility, unemployment rate by educational attainment, GDP per capita, and savings per capita.

The Model's disregard for time and country effects denotes its most significant limitation. The ISAFM Pooled OLS Model could be improved if more data were available, especially less tangible factors that strongly influence enrollments to Canadian universities like attitudes and perceptions entertained by potential international students.

Instrumental Variable Regression Using Three Stage Least Squares (3SLS)

Instrumental variable analysis is utilized for systems with several dependent variables. In the case of the ISAFM 3SLS Model, outbound student mobility was treated as a separate dependent variable in the following sense: An increase in international student enrollments is a function of larger numbers of outbound mobile students.

At the same time, the number of enrolled international students could lead to more outbound mobile student, because the next cohort of students will be more likely to follow. An instrumental variable regression was employed to address this problem of reverse causality.

Similar to the ISAFM OLS Model, the 3SLS Model employed a push and a pull model for Canada and BC's Top 20 sending countries, including the following independent variables:

- Population, age 20 to 24
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita

The international student enrollment forecast generated by the 3SLS Model depended on outbound mobility and the independent variables above. Outbound mobility itself was predicted using a similar set of independent variables. For example, population 20 to 24 year olds and GDP per capita denoted the most important predictors for outbound mobility, which by itself, served as a key predictor of international student enrollment in BC and Canada.

The ISAFM 3SLS Model could be improved by a more extensive analysis of what variables in the system are truly independent from each other through a more extensive literature analysis and surveys to ensure the equations were correctly specified.

A major limitation of this model is that it does not fully utilize the panel structure of the available data. Different sending countries were treated as homogenous and the Model assumes no time effects. Although there are methods that allow for the usage of instrumental variable techniques in a panel data framework, available data did not suffice to perform the estimation reliably.

Random Effects Model with Panel Data with Structural Time Changes

The ISAFM Random Effects Model used panel data to determine how historic trends influenced international student enrollments and used the resulting estimates to compute predictions about future international student mobility into Canada and BC.

The Random Effects Model utilizes an average of the time effects (the differences in enrollments that occur because of the independent variables changing over time) and the between effects (the difference in enrollments that occur because of variation in the independent variables between countries) to compute its estimates. The model assumes that the unobservable differences between countries are random and not correlated with any of the independent variables. Additionally, the model assumes, and can estimate, change time trends in the data.

Similar to the OLS Model, the ISAFM Random Effects Model forecasted enrollment levels for Canada's and British Columbia's Top 20 sending countries, employing the same push and pull logic used by other ISAFM models. After stress testing for collinear variables and statistical robustness, the best forecast was generated upon inclusion of the following independent variables:

- Population, age 20 to 24
- Number of outbound mobile students
- Canadian student visa approval rates (country-specific)
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita
- Daily foreign exchange rates with the Canadian Dollar
- Volatility of daily foreign exchange rates with the Canadian Dollar

The Random Effect Model explained 90 percent of the variation in enrollments of each sending country and 77 percent of the variation in enrollments between sending countries (88 percent overall). The most significant predictors of international student enrollment in the Model were outbound mobility and foreign exchange rate volatility. The Model tended to perform well in predicting enrollments from smaller sending countries and to under-predict student numbers from larger sending countries, leading to a more modest estimate of overall international student enrollment growth than other models.

A limitation of this model is that it ignores unobservable differences between countries. If there are unobservable differences between countries that are not

random then this model would over-attribute the effect of those differences to the independent variables leading to biased forecasts.

This model could be improved if more data were available, especially those unobserved factors that influence the flow of international students into Canada and BC, such as potential students' attitudes and perceptions concerning international education in Canada and BC.

System Dynamics

Introduction

System Dynamics allows for modeling interactions between elements of a complex system with the goal of reproducing its dynamic behavior.

In the case of ISAFM, the complex system consists of international students attaining higher education outside of their country of origin. Identifying the factors that influence the flow of international students is a multi-dimensional undertaking: political, economic, historical and cultural considerations must all be taken into account. System Dynamics provides a flexible framework to realize a modeling of these types of complex relationships.

It is important to stress that System Dynamics is not an alternative to statistical modeling techniques, but rather complements them. System Dynamics enables modelers to integrate expert opinions and less tangible factors into the statistical analysis. System Dynamics also enables modelers to simulate relevant scenarios, such as the effects of a currency crash.

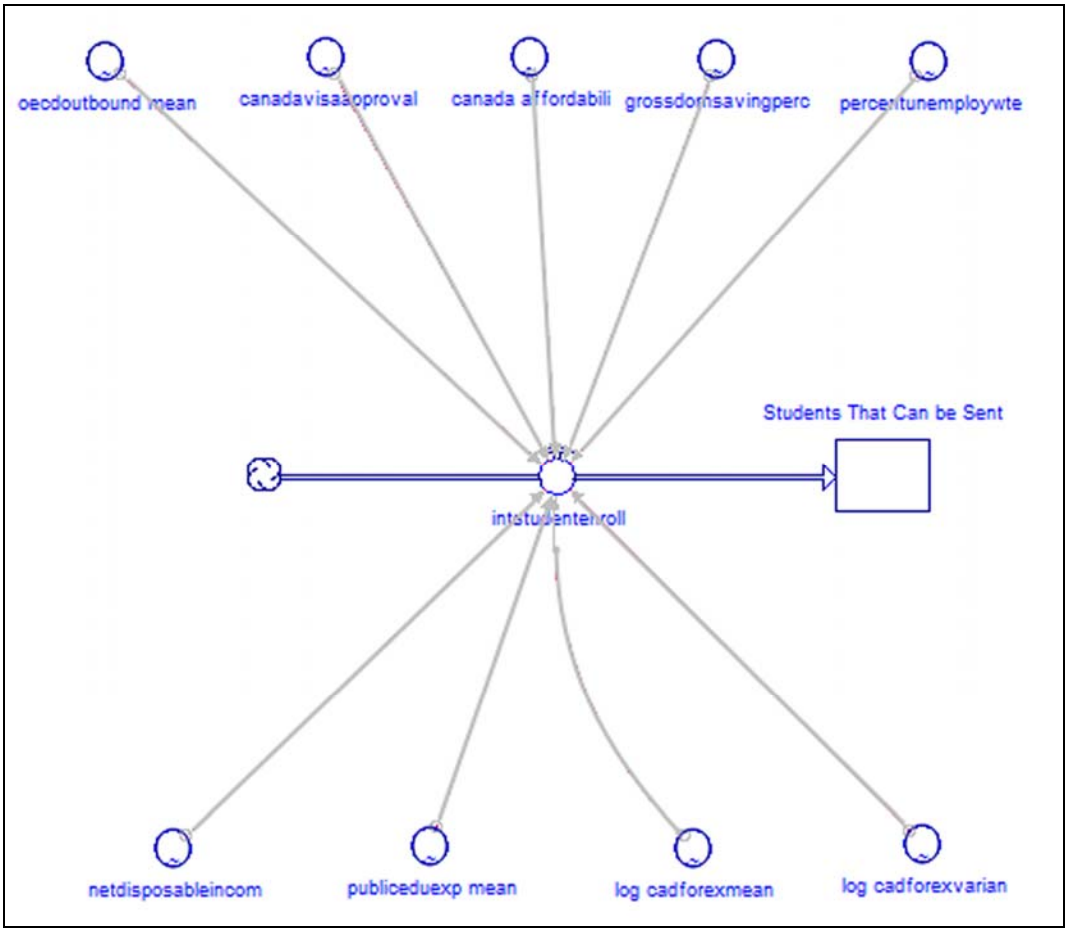
System Dynamics in ISAFM Version 1.1

For ISAFM Version 1.1, a system dynamics model was implemented in Stella. The model encompassed the Top 20 sending countries of international students in Canada. For each of the countries the model included a set of relevant exogenous variables that causally affect international student enrollment (see image below).

The causal effect was captured by a linear function with a coefficient for each variable that was calculated by least squares fitting and the inclusion of the following variables:

- Population, age 20 to 24
- Number of outbound mobile students
- Canadian student visa approval rates (country-specific)
- Canada affordability index (computed by comparing GDP per capita)
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita
- Daily foreign exchange rates with the Canadian Dollar
- Volatility of daily foreign exchange rates with the Canadian Dollar

ISAFM System Dynamics Flow Model for each Sending Country



Source: ISAFM.

In any complex system, several endogenous variables help determine system behavior. In order to account for these endogenous variables, the ISAFM System Dynamics Model included variables specific to the destination country (Canada), and which could affect the flow of international students. Examples include tuition fees, admissions requirements, etc.

An essential step in system dynamics modeling is testing the robustness of the model, for instance determining to what extent the model is sensitive to small variations in the values of the exogenous variables.

Further Development

In order to continue calibrating the ISAFM System Dynamics model and incorporating all the information available in a principled way, it will be necessary to iterate through the following steps:

- Incorporating boundary constraints on the model in order to make it robust and realistic. In particular, this includes enforcing certain capacity limits for destination countries and outbound limits for sending countries
- Determining what variables are relevant in each case. This will be realized by statistical analysis in the case of variables for which enough data are available. For the rest, the relevance will be evaluated by consulting experts and performing extensive simulations
- Quantifying the effects of the relevant variables on international student flows. This is one of the most challenging steps and will require testing a range of different alternatives. Again, both statistical analysis and input from specialists will be essential
- Testing the model under a wide range of conditions. This includes performing further sensitivity tests on the different parameters to ensure robustness

It will also be necessary to refine the structure of the model. Ideally, it would be desirable to identify endogenous variables, which have a causal effect on other variables in the model. This would be represented by feedback loops and delay structures.

Overall, further development of the ISAFM System Dynamics Model must constitute a joint effort involving careful quantitative analysis, exhaustive simulations, and expert evaluations.

Machine Learning Techniques

The main goal of machine learning algorithms is to *learn* the structure present in a dataset and exploit it to predict future outcomes. The techniques employed by the ISAFM Machine Learning Model were the following:

Ridge regression: An extension to linear regression that damps coefficients allowing for correlation between the independent variables.

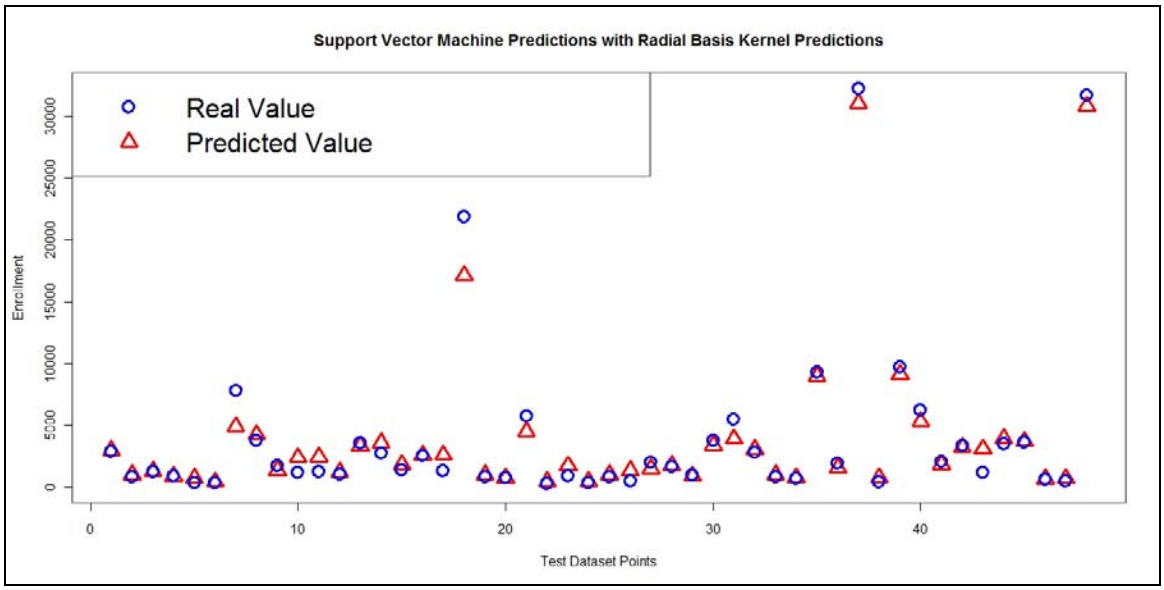
- Lasso: Another extension to linear regression that performs automatic selection of a subset of the independent variables.
- Random Forests: A classification technique that combines simple classifiers, which can be adapted to perform nonlinear regressions.
- Neural networks: A form of nonlinear regression inspired by biological neuron networks.
- Support vector machines: Nonlinear regression that is determined by a certain transformation of the independent variables, in the case of ISAFM polynomial and radial basis functions.

The amount of data available for each of Canada and BC's Top 20 sending country was too reduced to apply the above techniques to each country separately. The ISAFM Machine Learning Model was based on a larger dataset which was derived by pooling all sending countries together. Subsequently, a random subset of 75 percent of the data was drawn to train different algorithms and run several tests using the following independent variables:

- Population, age 20 to 24
- Number of outbound mobile students
- Canadian student visa approval rates (country-specific)
- Canada affordability index (computed by comparing GDP per capita)
- Gross domestic product per capita
- Public expenditures on education
- Unemployment rate by educational attainment
- Savings per capita
- Daily foreign exchange rates with the Canadian Dollar
- Volatility of daily foreign exchange rates with the Canadian Dollar

As shown in the image below, the support vector machines predictions generated the best fitting forecast of the five machine learning techniques employed by ISAFM.

Accuracy of International Student Enrollment Predictions by the Support Vector Machine Model with Radial Basis Kernel



Source: ISAFM.

The disregard for time series structure and country specificity denotes a key limitation of the ISAFM Machine Learning Model. In order to take the latter into account, it would be possible to group countries with similar characteristics and add an extra independent variable indicating what group the different countries belong to. As for the time series structure, introducing lagged variables may be useful for short term predictions.

Another important limitation is that many machine learning algorithms provide little information to allow for intuitive interpretations of their results. This does not mean that they cannot be useful. In fact, they consistently outperform other modeling techniques in many applications. It means that to employ them in the setting of international student mobility forecasting, it will be necessary to combine them with more intuitive modeling techniques and perform sanity checks on their predictions, for instance within the framework of system dynamics.

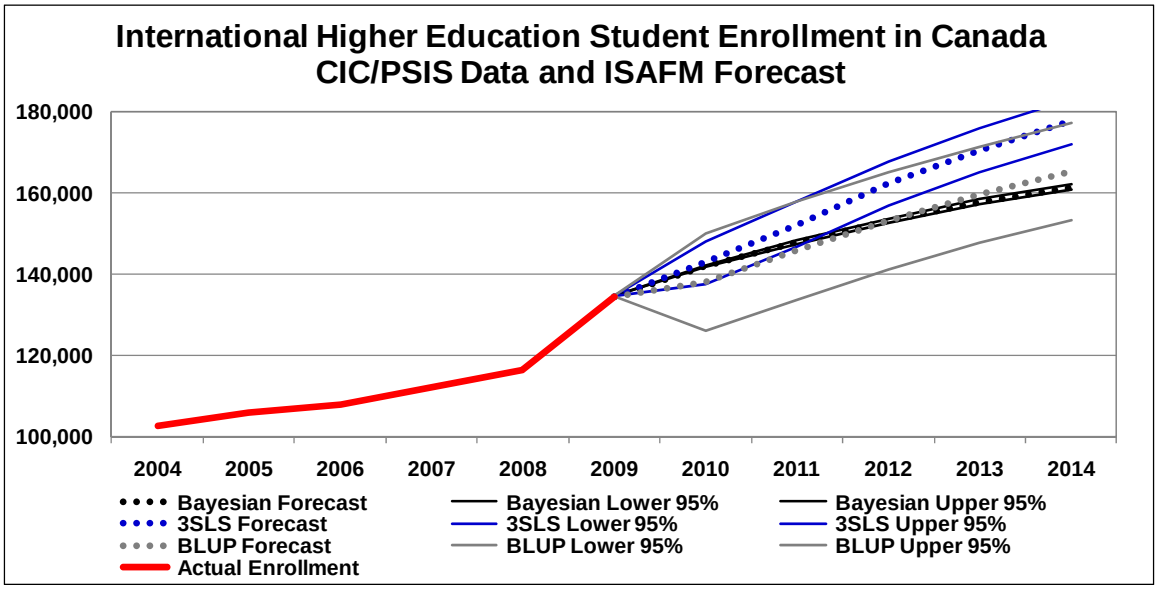
ISAFM FORECAST

Introduction

By employing a total of nine statistical modeling methods, ISAFM forecasted international student enrollment in Canada, British Columbia, as well as select higher education institutions out to 2014.

Depending on the modeling method employed, each forecast was generated at a 95 percent confidence interval. The confidence interval indicates the upper and lower forecast bounds which capture all possible future enrollment levels at a 95 percent confidence level.

International Student Enrollment in Canada (ISAFM Forecast with 95 Percent Confidence Intervals)

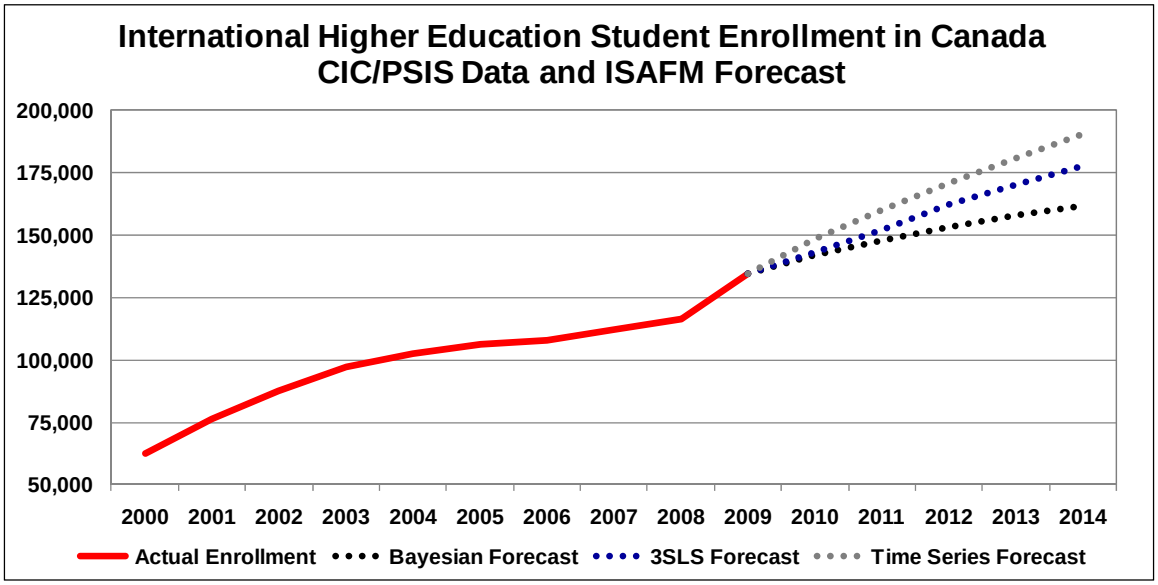


Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

The above graph depicts a forecast for the total enrollment of international higher education students in Canada. Confidence bounds are displayed for each of the three forecasting methods. Forecasts are displayed as dotted lines, which denote the mid-point of their respective confidence interval. For illustrative purposes confidence intervals were excluded from the following forecasts.

Canada

Total International Student Enrollment in Canada (ISAFM Forecast)



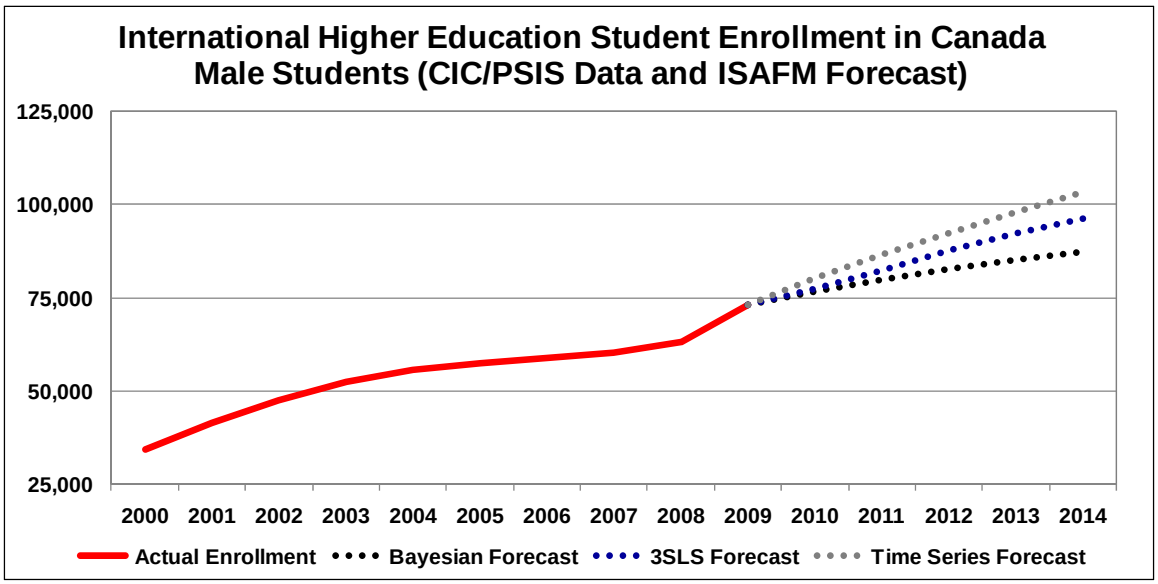
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, Canada's total enrollment of international higher education students increased from 62,229 to 134,564. A particularly strong increase could be observed in 2009 when student numbers grew by 15.7 percent.

The ISAFM Forecast indicated the following post-2009 growth potential for total international higher education student enrollment in Canada:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. Discontinuing the strong 2009 growth, total enrollments increased between two and five percent, reaching more than 160,000 international higher education students by 2014.
- The mid-point of the Three-Stage Least Squares (3SLS) Forecast indicated a potential for sustained future enrollment growth at a moderated level. At annual growth rates of between four and six percent, enrollment increased to close to 180,000 students by 2014.
- The mid-point of the Time Series Forecast indicated a potential increase at a substantial level, approaching 200,000 students by the end of the forecasting period.

Male International Student Enrollment in Canada (ISAFM Forecast)



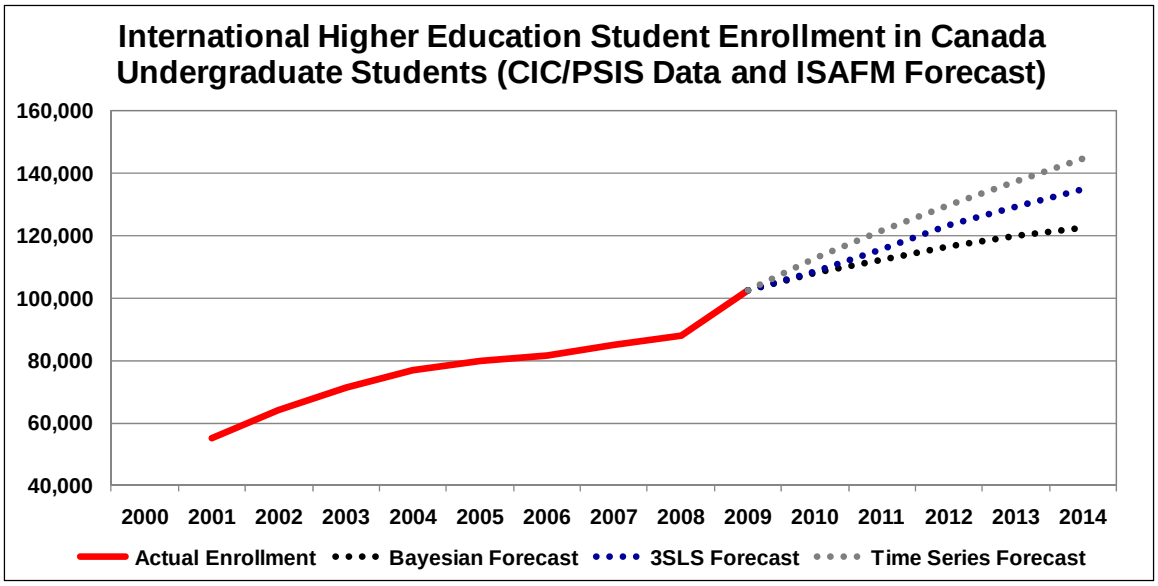
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, the total enrollment of male international students in Canadian higher education institutions increased from 34,426 to 73,065. A particularly strong increase could be observed in 2009 when enrollments grew by 15.9 percent. In 2009, 54.3 percent of international students in Canada were male.

The ISAFM Forecast indicated the following post-2009 growth potential for male international student enrollment in Canada:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. From 2010, the strong 2009 enrollment growth gradually leveled off at annual rates of two to five percent, reaching less than 90,000 male students by 2014.
- The mid-point of the 3SLS Forecast indicated a potential for sustained future enrollment growth at a moderated level. At annual growth rates of up to seven percent, enrollment increased to close to 100,000 male students five years out.
- The mid-point of the Time Series Forecast indicated a potential for an increase in male students at a substantial level. Student numbers grew by an annual rate of between five and ten percent, leading to the enrollment of an additional 30,000 male students between 2009 and 2014.

Undergraduate International Student Enrollment in Canada (ISAFM Forecast)



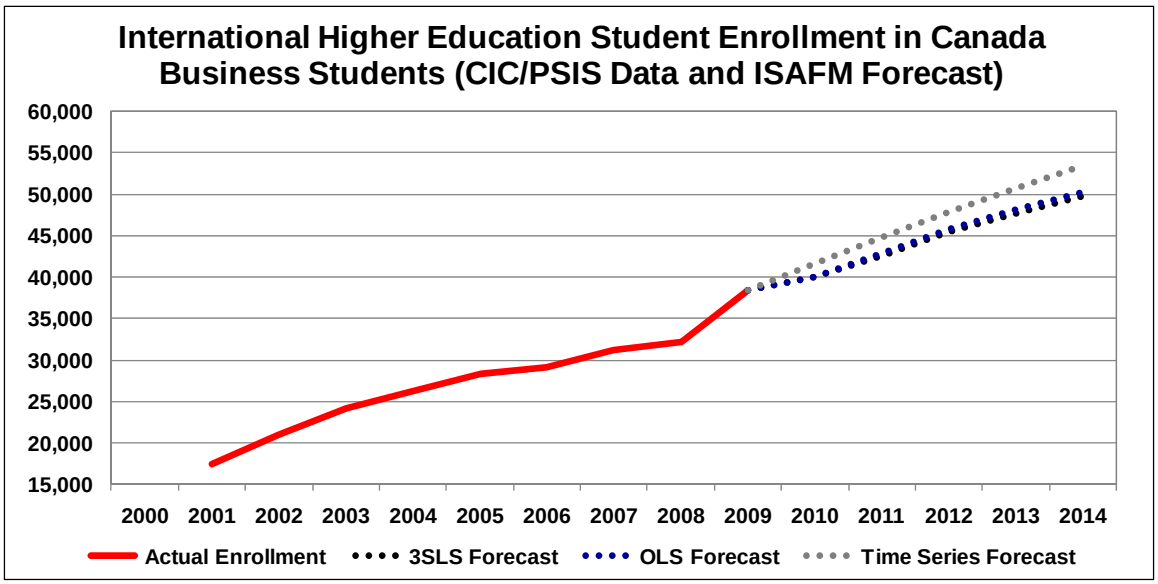
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Undergraduate students denote all students not enrolled in graduate programs as defined by PSIS.
Sources: CIC, PSIS, ISAFM.

Between 2001 and 2009, Canada's total enrollment of international undergraduate students increased from 55,018 to 102,597. International undergraduate student enrollment growth peaked in 2002 and 2009 at 16.5 percent respectively.

The ISAFM Forecast indicated the following post-2009 growth potential for Canada's international undergraduate student enrollment:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. Discontinuing the strong 2009 growth, enrollments increased by two to five percent, topping 120,000 international undergraduate students by the end of the forecasting period.
- The mid-point of the 3SLS Forecast indicated a potential for sustained future enrollment growth at a moderated level. At annual growth rates of between four and seven percent, enrollment increased to more than 130,000 undergraduate students five years out.
- The mid-point of the Time Series Forecast indicated a potential for an increase in undergraduate students at a substantial level, topping 140,000 students by 2014.

International Business Student Enrollment in Canada (ISAFM Forecast)



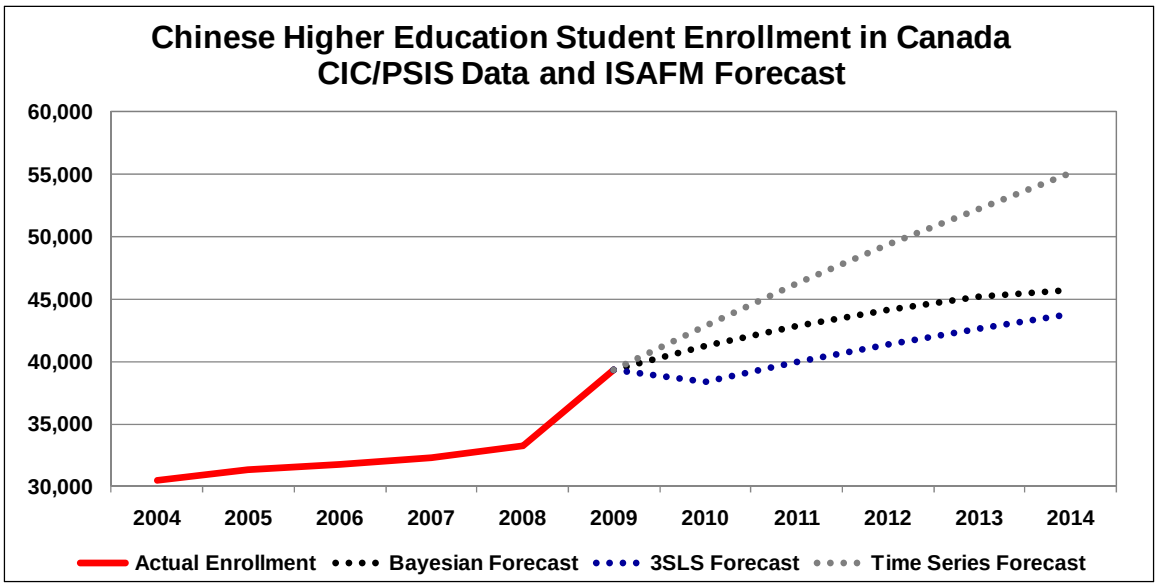
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2001 and 2009, the total number of Canada's international higher education students enrolled in Business programs increased from 17,436 to 38,399. In 2009, Business programs denoted Canada's most popular study field, attracting 28.5 percent of all international students.

The ISAFM Forecast indicated the following post-2009 growth potential for international student enrollment in Business programs at higher education institutions in Canada:

- The mid-point of the 3SLS Forecast indicated a potential for future enrollment growth at a substantial level. After a strong increase in 2009, enrollment growth continued to hover around five percent, resulting in more than 11,000 additional international Business students by 2014.
- The mid-point of the Pooled Ordinary Least Squares (OLS) Forecast indicated a potential for future enrollment growth at a substantial level, topping 50,000 students five years out.
- The mid-point of the Time Series Forecast indicated a potential for future enrollment growth at a substantial level. Annual growth rates of between five to eight percent led to a total enrollment level of close to 55,000 international Business students by 2014.

Chinese Student Enrollment in Canada (ISAFM Forecast)



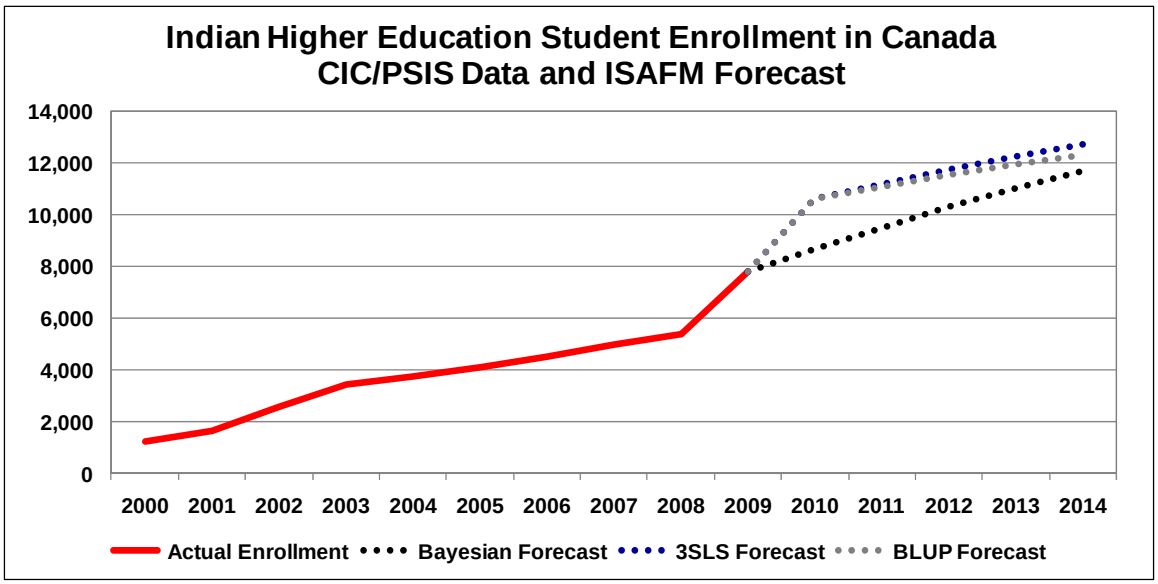
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Time series forecasts were generated based on constant 2007-2009 enrollment shared held by Chinese students. Actual enrollments for 2000 through 2003 were excluded for illustration purposes.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, the total enrollment of Chinese higher education students in Canada showed a close to six-fold increase, from 7,155 students to 39,373. In 2009, Chinese students comprised 29.3 percent of Canada's total international student population.

The ISAFM Forecast indicated the following post-2009 growth potential for Chinese student enrollment in Canada:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. At annual enrollment growth rates between one and five percent, student numbers gradually rose to top 45,000 by the end of the forecasting period.
- The mid-point of the 3SLS Forecast indicated a potential for a low-level overall enrollment increase five years out. The magnitude of the eventual growth was primarily driven by a notable drop in 2010.
- The mid-point of the Time Series Forecast indicated a potential for a sustained increase in Chinese higher education students at a substantial level, reaching close to 55,000 students by 2014.

Indian Student Enrollment in Canada (ISAFM Forecast)



Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

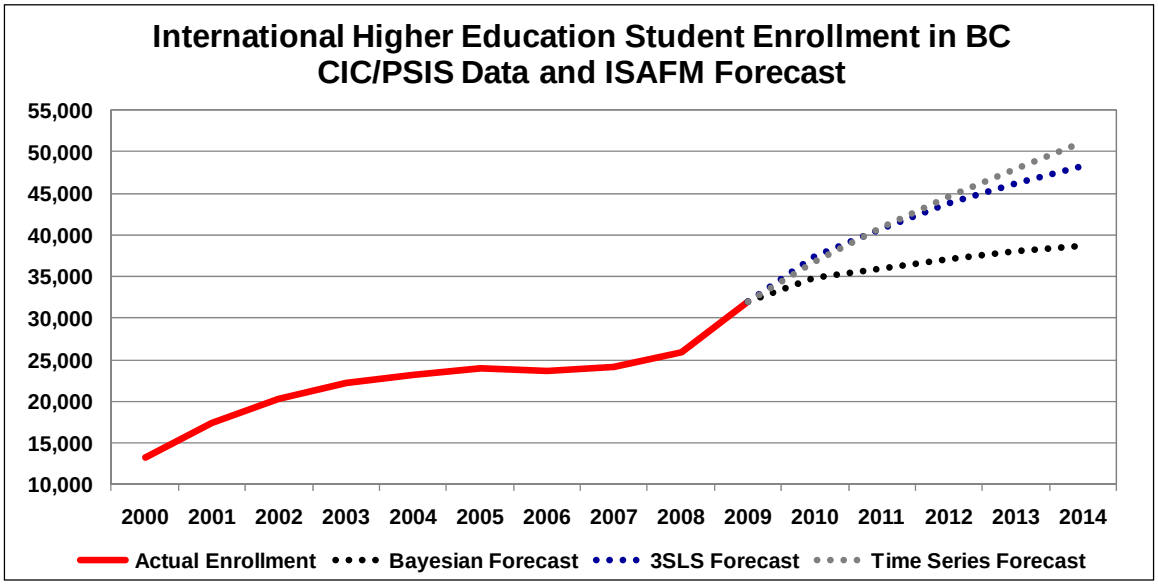
Between 2000 and 2009, Indian higher education student enrollment increased from 1,224 to 7,822. The strong 45.4 percent increase in 2009 denoted the largest jump since 2002 when enrollments grew by 53.1 percent.

The ISAFM Forecast indicated the following post-2009 growth potential for Indian higher education student enrollment in Canada:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. At annual growth rates between five and eleven percent, the number of Indian students at Canadian higher education institutions rose to close to 12,000 by 2014.
- The mid-point of the 3SLS Forecast indicated a potential for a long-term enrollment increase at a moderated level. After substantial growth in 2010, the number of Indian students increased at lower growth rates to close to 13,000 five years out.
- The mid-point of the Time Series Forecast indicated a potential for enrollment growth at a moderated level. Largely mirroring the 3SLS Forecast, the mid-point of the Time Series Forecast indicated enrollment growth to more than 12,000 Indian students by the end of the forecasting period.

British Columbia

Total International Student Enrollment in BC (ISAFM Forecast)



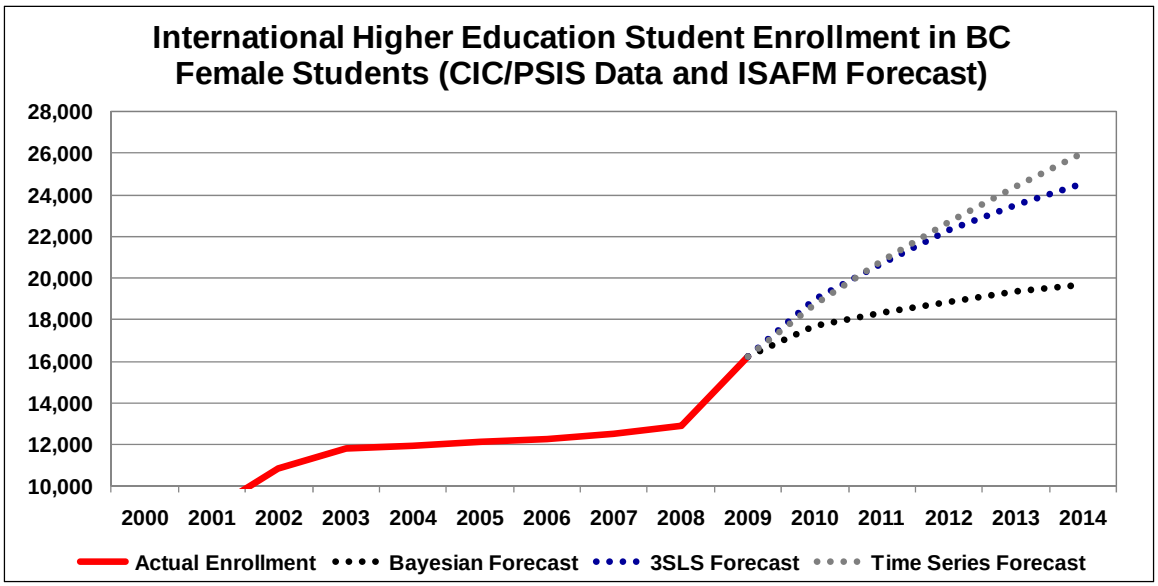
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, British Columbia's total enrollment of international higher education students increased by 141.9 percent, from 13,220 to 31,979. A particularly strong increase could be observed in 2009 when student numbers grew by 23.6 percent.

The ISAFM Forecast indicated the following post-2009 growth potential for total international higher education student enrollment in British Columbia:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. Discontinuing the strong 2009 growth, total enrollments increased between two and nine percent, reaching just fewer than 40,000 international higher education students by 2014.
- The mid-point of the Three-Stage Least Squares (3SLS) Forecast indicated a potential for sustained future enrollment growth at a substantial level. At annual growth rates of between four and 16 percent, enrollment increased to close to 50,000 students by 2014.
- The mid-point of the Time Series Forecast indicated a potential increase at a substantial level, topping 50,000 students by the end of the forecasting period.

Female International Student Enrollment in BC (ISAFM Forecast)



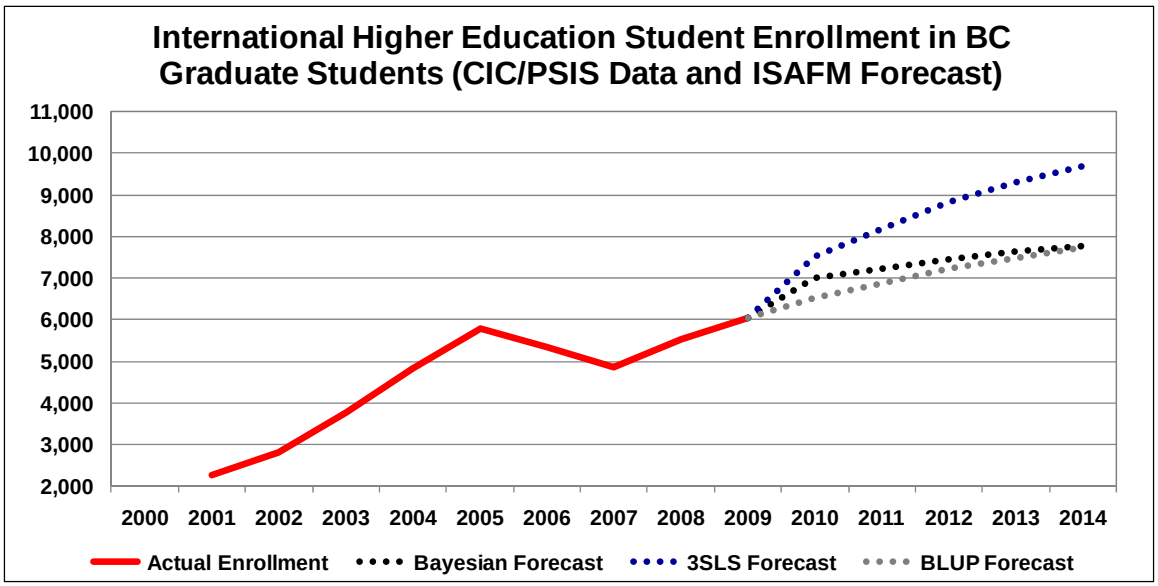
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Actual enrollments for 2000 through 2001 were excluded for illustration purposes.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, the total number of female international students in British Columbia-based higher education institutions grew from 6,596 to 16,239. The strongest growth occurred in 2009 when enrollments increased by 25.6 percent. In 2009, BC's international student population was 50.8 percent female.

The ISAFM Forecast indicated the following post-2009 growth potential for female international student enrollment in British Columbia:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. From 2010, a leveling off of the strong increases observed in 2009 led to a total number of close to 20,000 female students by 2014.
- The mid-point of the Three-Stage Least Squares (3SLS) Forecast indicated a potential for sustained future enrollment growth at a substantial level. After continuing the strong 2009 growth trajectory in 2010, enrollment growth gradually slowed down, resulting in a total enrollment of over close to 25,000 female students by the end of the forecasting period.
- The mid-point of the Time Series Forecast indicated a potential for an increase in enrollments at a substantial level, reaching more than 26,000 female students enrolled at higher education institutions in British Columbia.

Graduate International Student Enrollment in BC (ISAFM Forecast)



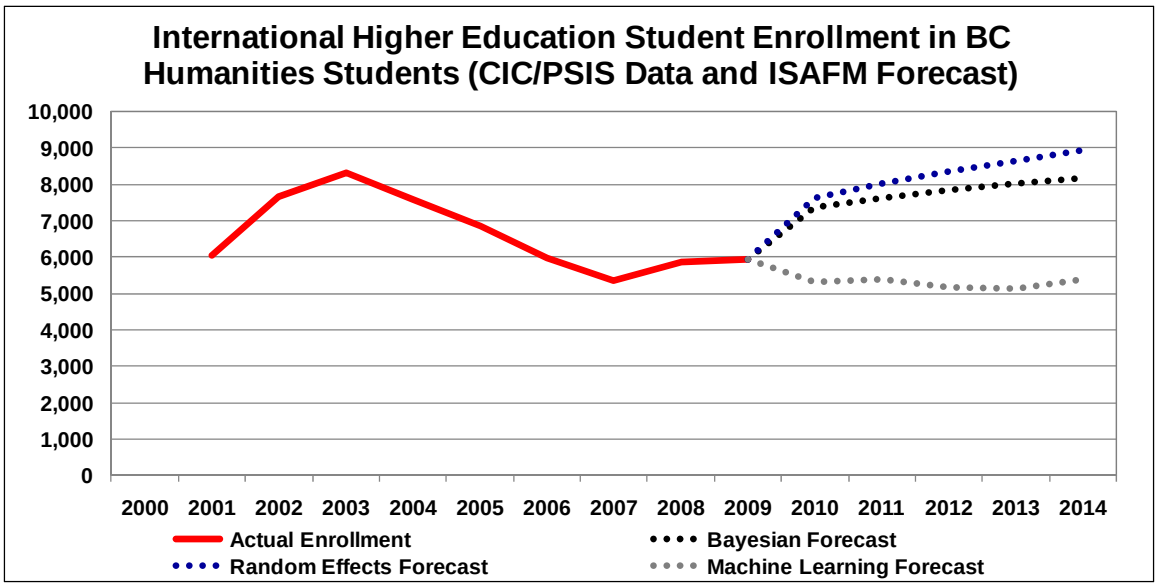
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2001 and 2009, British Columbia's international graduate student population exhibited a mixed growth pattern, falling from 5,792 in 2005 to 4,851 in 2007, before rising to 6,041 students in 2009.

The ISAFM Forecast indicated the following post-2009 growth potential for international graduate students in British Columbia:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a moderated level. After a strong increase in 2010, growth rates leveled off rapidly, indicating a total enrollment of just under 8,000 international graduate students by 2014.
- The mid-point of the 3SLS Forecast indicated a potential for future enrollment growth at a substantial level. After a strong increase in 2010, enrollments rose at annual growth rates of between four and nine percent, reaching a total of close to 10,000 graduate students five years out.
- The mid-point of the Best Linear Unbiased Prediction (BLUP) Forecast indicated a potential for sustained future enrollment growth at a moderated level, reaching just under 8,000 by the of the forecasting period.

International Humanities Student Enrollment in BC (ISAFM Forecast)



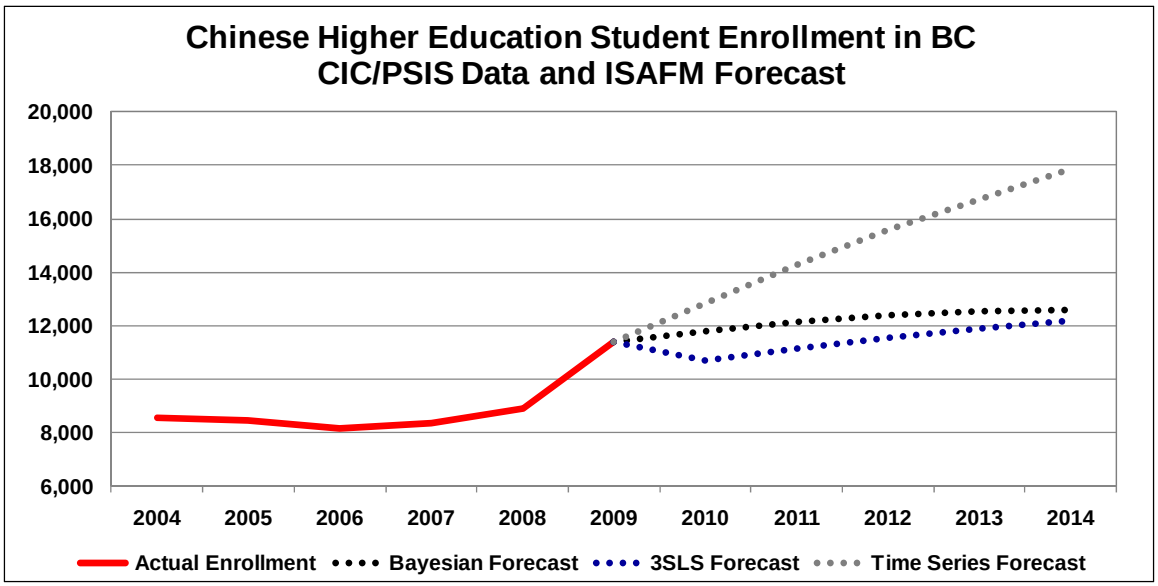
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2001 and 2009, British Columbia's international higher education students enrolled in Humanities programs exhibited four consecutive years of decline in total numbers, from 8,307 in 2003 to 5,355 in 2007. After bringing the decrease to a halt in 2008 and 2009, BC's Humanities programs enrolled a total of 5,938 international students in 2009.

The ISAFM Forecast indicated the following post-2009 growth potential for international students enrolled in Humanities programs at British Columbia-based higher education institutions:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a substantial level. After a strong increase in 2010, growth slowed down to annual growth rates of one to three percent, resulting in total enrollments of more than 8,000 students five years out.
- The mid-point of the Random Effects Regression Forecast indicated a potential for future enrollment growth at a substantial level. Following a strong increase in student numbers in 2010, growth rates decreased to three to five percent, leading to a 2014 enrollment level of just under 9,000 students.
- The mid-point of the Machine Learning Forecast indicated a potential for future enrollment decline at a moderated level, remaining between 5,000 and 6,000 students by the end of the forecasting period.

Chinese Student Enrollment in BC (ISAFM Forecast)



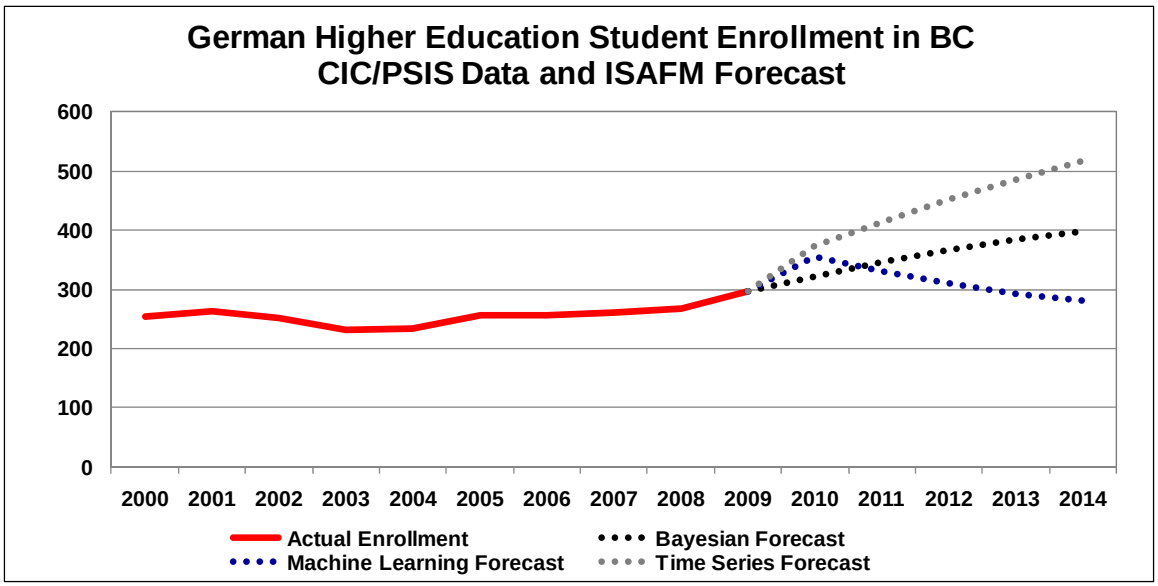
Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Time series forecasts were generated based on constant 2007-2009 enrollment shared held by Chinese students. Actual enrollments for 2000 through 2003 were excluded for illustration purposes.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2009, the total enrollment of Chinese higher education students in British Columbia showed a close to six-fold increase, from 1,969 students to 11,412. In 2009, Chinese students made up 35.7 percent of British Columbia's total international student population.

The ISAFM Forecast indicated the following post-2009 growth potential for Chinese student enrollment in British Columbia:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a low level. At annual enrollment growth rates between one and four percent, student numbers gradually rose to between 12,000 and 13,000 by the end of the forecasting period.
- The mid-point of the 3SLS Forecast indicated a potential for a low-level overall enrollment increase five years out. The magnitude of the eventual growth was primarily driven by a notable drop in 2010.
- The mid-point of the Time Series Forecast indicated a potential for a substantial increase in Chinese higher education students. After continuing the 2009 trajectory based on gradually shrinking growth rates between seven and 13 percent, Chinese student numbers totaled close to 18,000 by 2014.

German Student Enrollment in BC (ISAFM Forecast)



Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Time series forecasts were generated based on constant 2007-2009 enrollment shared held by German students.
Sources: CIC, PSIS, ISAFM.

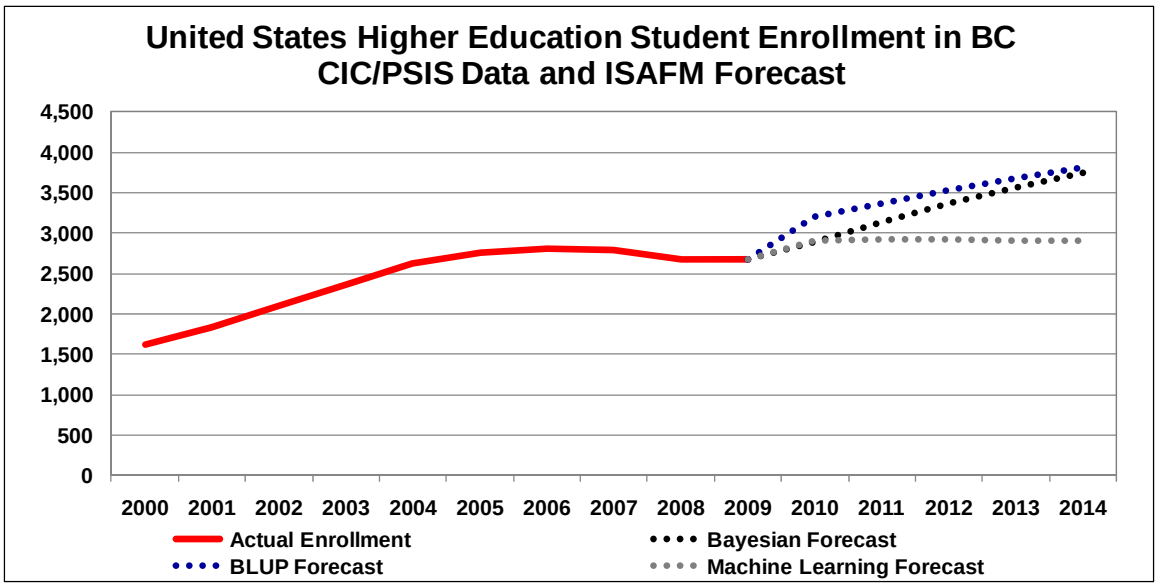
Between 2000 and 2009, British Columbia students originating from Germany exhibited minor deviations from their ten year mean of 257. By 2009, the number of German students enrolled at the Province's higher education institutions totaled close to 300.

The ISAFM Forecast indicated the following post-2009 growth potential for German higher education student enrollment in British Columbia:

- The mid-point of the Bayesian Forecast indicated potential for future enrollment growth at a moderated level. Continuing the 2009 growth trajectory, student number gradually rose to close to 400 by 2014.
- The mid-point of the Machine Learning Forecast indicated potential for long-term enrollment decline at a moderated level. After a substantial increase in 2010, the number of German students decreased steadily to less than 300 five years out.
- The mid-point of the Time Series Forecast indicated potential for strong enrollment growth, topping 500 higher education students by the end of the forecasting period.

The size of BC's recruiting footprint in Germany preconditioned a larger relative forecasting range.

United States Student Enrollment in BC (ISAFM Forecast)



Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
Sources: CIC, PSIS, ISAFM.

Between 2000 and 2006, the total enrollment of US students in higher education institutions in British Columbia showed a steady increase, from 1,618 students to 2,800. After minor enrollment declines in 2007 and 2008, the US continued to rank among BC's Top 3 sending countries, with a 2009 total enrollment of 2,674 students.

The ISAFM Forecast indicated the following post-2009 growth potential for US higher education student enrollment in British Columbia:

- The mid-point of the Bayesian Forecast indicated a potential for future enrollment growth at a substantial level. At annual enrollment growth rates of up to eight percent, US student numbers increased steadily to more than 3,500 five years out.
- The mid-point of the BLUP Forecast indicated a potential for a substantial overall increase in enrolments to close to 4,000 US students by 2014.
- The mid-point of the Machine Learning Forecast indicated a potential for a low increase in US student enrollments. After increasing in 2010, student numbers hovered around just under 3,000 until the end of the forecasting period.

Okanagan College, Capilano University, Simon Fraser University

Data analysis and modeling for the three pilot institutions Okanagan College, Capilano University, and Simon Fraser University was subject to agreements with these institutions as well as regulatory and privacy constraints regarding the publication of student enrollment data.

Therefore, this report does not include a discussion of these institutions. Any such discussion is confined to reports which are non-public and which have been made available to the respective institutions.

IMPLICATIONS AND STRUCTURAL CONSIDERATIONS

Perspectives on Enrollment Trends: Why Granularity is Critical

ISAFM forecasts near-term trends for international student enrollments. One of the unique value contributions of this forecast is based on its granularity which considers subject matter, degree level, and gender sub-variables. If data availability allows, these attributes are employed in a matrix approach which segments and maps students at a highly in-depth level.

Once trends are considered at such a granular level, it becomes apparent that variation and susceptibility to disruptive and/or formative factors increases significantly in certain student segments. From a marketing and recruiting standpoint, these segments matter significantly more than topline numbers. Reasons include:

- In the case of gender, this sub-variable is impacted by differing achievement levels (women outperform men in most situations and exhibit a different subject matter enrollment pattern).
- In the case of subject matter choice (which can be heavily skewed by sending country as well as by gender as mentioned above).
- In the case of degree level (which is subject to specific sending country demand patterns as well as destination country specific degree track offerings and brand strength).

The deepest level of granularity ISAFM can offer would be the combination of sending and receiving country, gender, degree level, and subject matter chosen – such as for the example of a Chinese female undergraduate engineering student studying in Canada.

Attaining such a level of granularity is entirely depended on data availability. Only a few countries have collected international student data at this (matrix) level, and a good number of these countries do not make such data publicly available. Many more countries offer “table-based” data which covers these three sub-variables on a stand-alone basis.

Many higher education institutions are in a different position because they can draw on such highly granular data from their own databases. Thus, granular forecasts are typically more readily possible at an institutional level rather than at a national level or state/provincial level.

Mapping Data, Policy and Capability

A key methodological aspect of ISAFM is based on its being embedded in institutional, system, and national policy analysis. Any actionable strategic advice is derived from this embedding rather than from a standardized, one-size-fits-all approach. Without this embedding, ISAFM would offer salient but difficult to interpret data – which would lack critical contextualization and therefore open the door to imprecise decision making.

Contextualization takes place in two ways. First, within the accelerated global competition landscape more countries as well as more institutions have begun to actively recruit international students – demand for students has therefore increased notably.

This trend has been well documented across multiple dimensions, ranging from increased marketing spending by governments and institutions, to rising participation in international education conferences, to the emergence of a large volume of student discussions in social communities such as Facebook.

From a student perspective, many consider a range of options with regards to destination countries, and in most cases, the choice of a receiving institution. Student supply has thus not only increased numerically but also grown more diverse and more complex to understand; it certainly is not taking place in a competitive vacuum.

Second, the interplay of these two trends – also otherwise referred to as push and pull factors – has resulted in a plethora of aspects to consider. At its core, this requires interpreting available data which in a second step need to be mapped to the context of the client. This context is composed of the respective education system (or institution), as well as policy design and execution landscape.

This is a critical step in the ISAFM analytical framework. For example, a client might expect a further strong demand from Chinese undergraduate students based on the ISAFM baseline forecast. However, this demand dynamic would run counter to a shift towards graduate recruiting, coupled with a cap on overall international student enrollments.

Increasingly, institutions and popular destinations (localities) are also reaching capability, delivery, and absorption limits. These limits reflect on scale issues, quality maintenance requirements, student body diversification paradigms, available housing, and a set of policy issues pertaining to visa regulations, work force entry, and migration. Any assumption that international student enrollments are bound to grow in perpetuity would thus be misplaced. Indeed, ceiling effects are already beginning to manifest themselves in many destination countries.

Diversification, Risk, and Proactive Management

Over the last five years, a strongly emerging theme in international education has been the development of highly concentrated student in-take patterns (with regards to certain sending countries) on the one hand and subject matter selection on the other hand.

While these concentration patterns differ amongst receiving countries and receiving institutions (as well as at a subject and degree level), sending countries which have contributed substantially to this dynamic include China, India, South Korea, and more recently Saudi Arabia. The USA has also emerged as a major contributor to students going abroad albeit dominantly in a non-degree, exchange mode.

In terms of subject matter choice, students from certain sending countries exhibit strong concentration behavior as well. For example, around three quarters of Indian students in the USA are enrolled in three study fields – Business, Economics, and Management; Engineering; and ICT / IT / CS.

In cases where both concentration trends take place, “mono cultures” have developed. This lack of diversification in a country’s or institution’s international student pool has introduced multiple risk factors:

- Technical risk based on elevated source dependency.
- Political risk owing to external interference and domestic backlash.
- Educational risk owing to learning, teaching, and quality challenges.
- Business planning, investment, and continuance risk.

ISAFM allows for a proactive risk mitigation approach. This approach considers a client’s ability to govern its future international student intake patterns by mapping externally driven student supply patterns to internal capabilities, capacity, and policy preferences.

In this instance, ISAFM’s analytical power is heightened by the fact that the origin of these mono cultures can typically be identified in preceding years. Even simply on the basis of emerging data and the absence of a forecast beyond three years into the future, ISAFM is capable of early pattern recognition which enables proactive risk management.

SUMMARY: COMPETITIVE ADVANTAGE THROUGH EVIDENCE-BASED ANALYSIS

International student education is on track to continue its overall growth pattern. In the not so distant future, the four million student mark will be reached. At this level, the number of international students will be the equivalent to the population of Liberia or Bosnia and Herzegovina. This makes the pool of international students a demographic force to be reckoned with.

From an economic point of view, international education has grown into an industry with an economic impact estimated by ICG at more than USD 80 billion in key countries as defined in the ISAFM data model. In some countries such as Australia or New Zealand, international education has become a significant national revenue source.

The emergence of a large pool of young mobile talent, coupled with a multi-billion dollar spending ability, has induced a more and more competitive landscape – both at a national as well as at an institutional level. Over the last decade, states and provinces as well as metro areas have also staked out their positions.

The result has been a notable increase in competition levels – and the trend towards hyper competition scenarios in some markets and some student segments. In order to rationally manage this competition landscape – whether at an institutional, regional, or national level – it is essential to base decision-making on the best possible set of information, analysis, and contextualization possible.

ISAFM addresses this need by clearly separating information, analysis, and contextualization from one another. ISAFM also maintains methodological clarity by not allowing a client's context or outcome expectations to interfere with information gathering and analysis since this would create self-defeating feedback loops.

ISAFM constitutes a marked departure from past and current international education analysis and forecasting practices which treat forward-looking predictions of international student enrollments as a political and/or ad hoc endeavor with a limited desire for objective, evidence-based analysis.

Clients deploying ISAFM can expect a rational, objective, and evidence-based analysis and forecast which takes into account an unprecedented range of data points and variables. Through a multitude of forecasting and modeling approaches, the ISAFM utilizes the wide breadth of data to arrive at the best possible forecast. . The outcome for clients is competitive advantage through evidenced-based analysis and rational decision-making.

APPENDIX

ISAFM Study Fields

ISAFM higher education enrollment data utilize a harmonized list of eleven internationally comparable study fields which were derived from international benchmark research:

- Business, Economics, Management
- Education
- Engineering
- Humanities / Arts
- ICT / IT / CS
- Law
- Medicine / Life Sciences / Health
- Natural Sciences
- Professional
- Social Sciences
- Others

ICG employs a proprietary mapping table which harmonizes study field definitions in any given country to the above list.

Countries in the ISAFM Data Model

- Afghanistan
- Albania
- Algeria
- Angola
- Argentina
- Armenia
- Australia
- Austria
- Azerbaijan
- Bahamas
- Bahrain
- Bangladesh
- Barbados
- Belarus
- Belgium
- Benin
- Bermuda
- Bolivia
- Bosnia and Herzegovina
- Botswana
- Brazil
- Brunei Darussalam
- Bulgaria
- Burkina Faso
- Cambodia
- Cameroon
- Canada
- Cape Verde
- Chad
- Chile
- China
- Colombia
- Comoros
- Congo
- Costa Rica
- Côte d'Ivoire
- Croatia
- Cuba
- Cyprus
- Czech Republic
- Democratic People's Republic of Korea
- Democratic Republic of the Congo
- Denmark
- Djibouti
- Dominican Republic
- Ecuador
- Egypt
- El Salvador
- Estonia
- Ethiopia
- Fiji
- Finland
- France
- Gabon
- Georgia
- Germany
- Ghana
- Greece
- Guatemala
- Guinea
- Haiti
- Honduras
- Hong Kong (China), SAR
- Hungary
- Iceland
- India
- Indonesia
- Iran, Islamic Republic of
- Iraq
- Ireland
- Israel
- Italy
- Jamaica
- Japan
- Jordan
- Kazakhstan
- Kenya
- Kuwait
- Kyrgyzstan
- Lao People's Democratic Republic
- Latvia
- Lebanon
- Lesotho
- Libyan Arab Jamahiriya
- Lithuania
- Luxembourg
- Macao, China
- Madagascar
- Malawi
- Malaysia
- Maldives
- Mali
- Malta
- Mauritania
- Mauritius
- Mexico
- Mongolia
- Montenegro
- Morocco
- Mozambique
- Myanmar
- Namibia
- Nepal
- Netherlands
- New Zealand
- Nicaragua
- Niger
- Nigeria
- Norway
- Oman
- Pakistan
- Palestinian Autonomous Territories
- Panama
- Paraguay
- Peru
- Philippines
- Poland
- Portugal
- Qatar
- Republic of Korea
- Republic of Moldova

- Romania
- Russian Federation
- Rwanda
- Saudi Arabia
- Senegal
- Serbia
- Singapore
- Slovakia
- Slovenia
- Somalia
- South Africa
- Spain
- Sri Lanka
- Sudan
- Swaziland
- Sweden
- Switzerland
- Syrian Arab Republic
- Taiwan
- Tajikistan
- Thailand
- The Former Yugoslav Republic of Macedonia
- Timor-Leste
- Togo
- Trinidad and Tobago
- Tunisia
- Turkey
- Turkmenistan
- Uganda
- Ukraine
- United Arab Emirates
- United Kingdom
- United Republic of Tanzania
- United States
- Uruguay
- Uzbekistan
- Venezuela
- Viet Nam
- Yemen
- Zambia
- Zimbabwe

Source: ICG.

Key Countries in the ISAFM Model

- Albania
- Algeria
- Australia
- Austria
- Bangladesh
- Belarus
- Belgium
- Bosnia and Herzegovina
- Brazil
- Bulgaria
- Cameroon
- Canada
- China
- Colombia
- Cyprus
- Denmark
- France
- Germany
- Greece
- Hong Kong (China), SAR
- Senegal
- Singapore
- India
- Indonesia
- Iran, Islamic Republic of
- Ireland
- Israel
- Italy
- Japan
- Kazakhstan
- Kenya
- Lebanon
- Malaysia
- Mexico
- Morocco
- Nepal
- Netherlands
- New Zealand
- Nigeria
- Norway
- Pakistan
- Peru
- Poland
- Republic of Korea
- Romania
- Russian Federation
- Saudi Arabia
- Slovakia
- South Africa
- Spain
- Sri Lanka
- Sweden
- Switzerland
- Syrian Arab Republic
- Thailand
- Tunisia
- Turkey
- Ukraine
- United Kingdom
- United States
- Uzbekistan
- Venezuela
- Viet Nam
- Zimbabwe

Source: ICG.