THE AGE OF ANALYTICS

CBIE 2011 Conference

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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.**
- **Alexander Lundberg, M.Sc.**
  - **Mr. Lundberg recently graduated with a M.Sc. in Econometrics and Mathematical Economics from the London School of Economics. He is serving as the 2011 Quantitative Analysts Intern with a focus on ISAFM.**
- **Mauro Mondino, MPP**
  - **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.**

ISAFM MODELING TEAM

- **Andrea A. Abel, Ph.D.**
  - **Ms. Abel completed 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.**
- **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.**
- **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.**
- **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.**

ISAFM ADVISORY BOARD MEMBERS (I)

- **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.**
- **Dr. John E. Andersen. Director of International Affairs at the University of Copenhagen, Denmark, and chairman of the Danish Rectors' Conference Committee for International Relations.**
- **Britta Baron. Vice-Provost and Associate Vice President International at the University of Alberta, Canada.**
- **Paul Brennan. Vice-President for International Partnerships at the Association of Canadian Community Colleges, Canada.**
- **Prof. Sheila Embleton. Past Vice-President Academic and Provost at York University, Canada.**
- **Dr. Andy Gillespie. Assistant Provost for International Program at Auburn University, USA.**
- **Prof. Nigel Healy. Pro-Vice-Chancellor at the University of Canterbury, New Zealand (transitioning to the UK).**

ISAFM ADVISORY BOARD MEMBERS (II)

- **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 APAIE.**
- **Joy McKinnon, DBA. Vice President of Business Development at Algonquin College, Canada.**
- **Dr. Randall Martin. Executive Director of the British Columbia Council for International Education, Canada, and former Director of SFU International.**
- **Gonzalo Peralta. Executive Director of Languages Canada, Canada, and past 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 EAIE**

ISAFM RESEARCH PARTNERS

- **System Dynamics Group at the University of Bergen (Prof. Pal Davidson)**
  - **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.**

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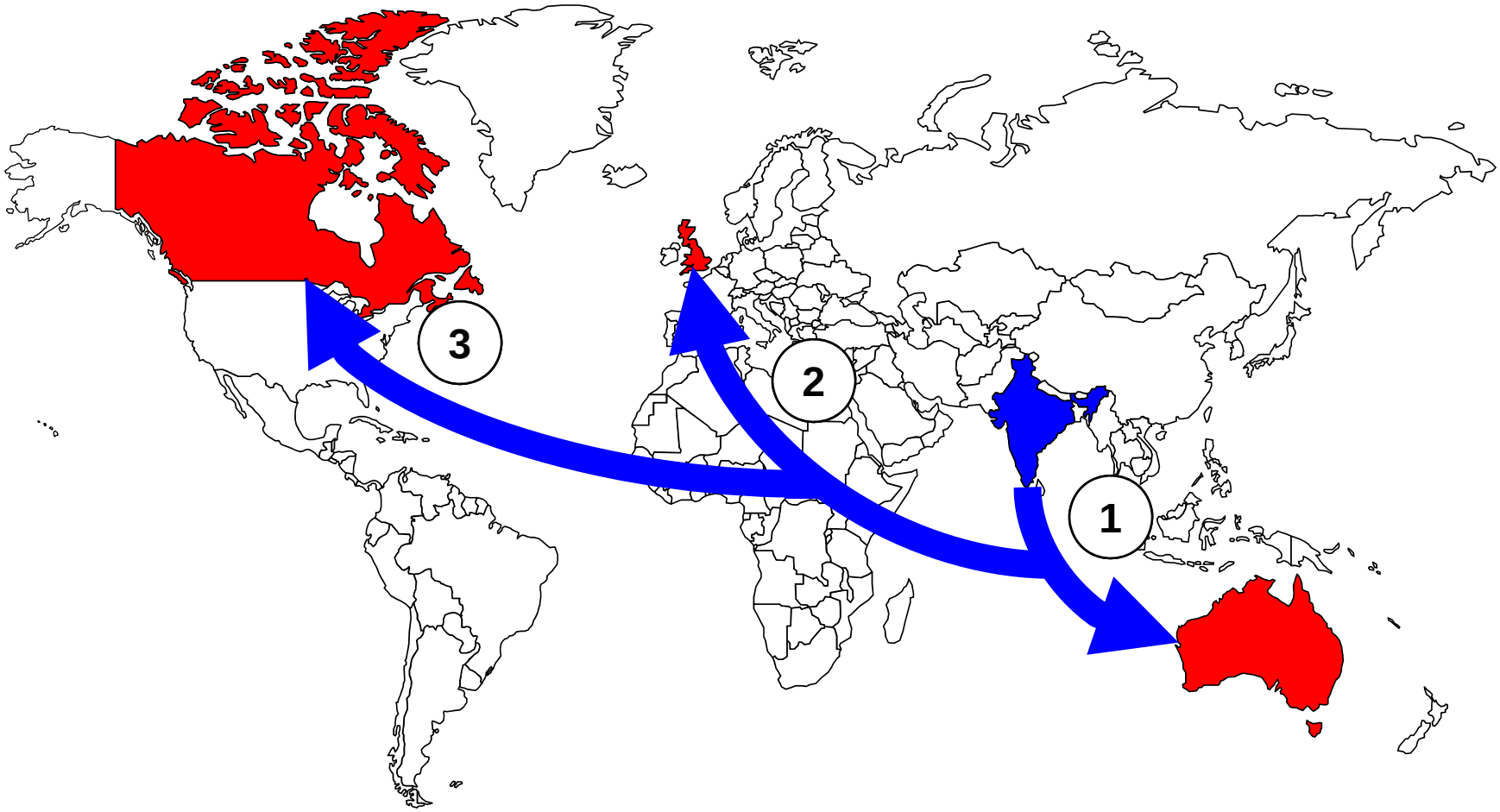
INTERNATIONAL STUDENT EDUCATION FLOWS



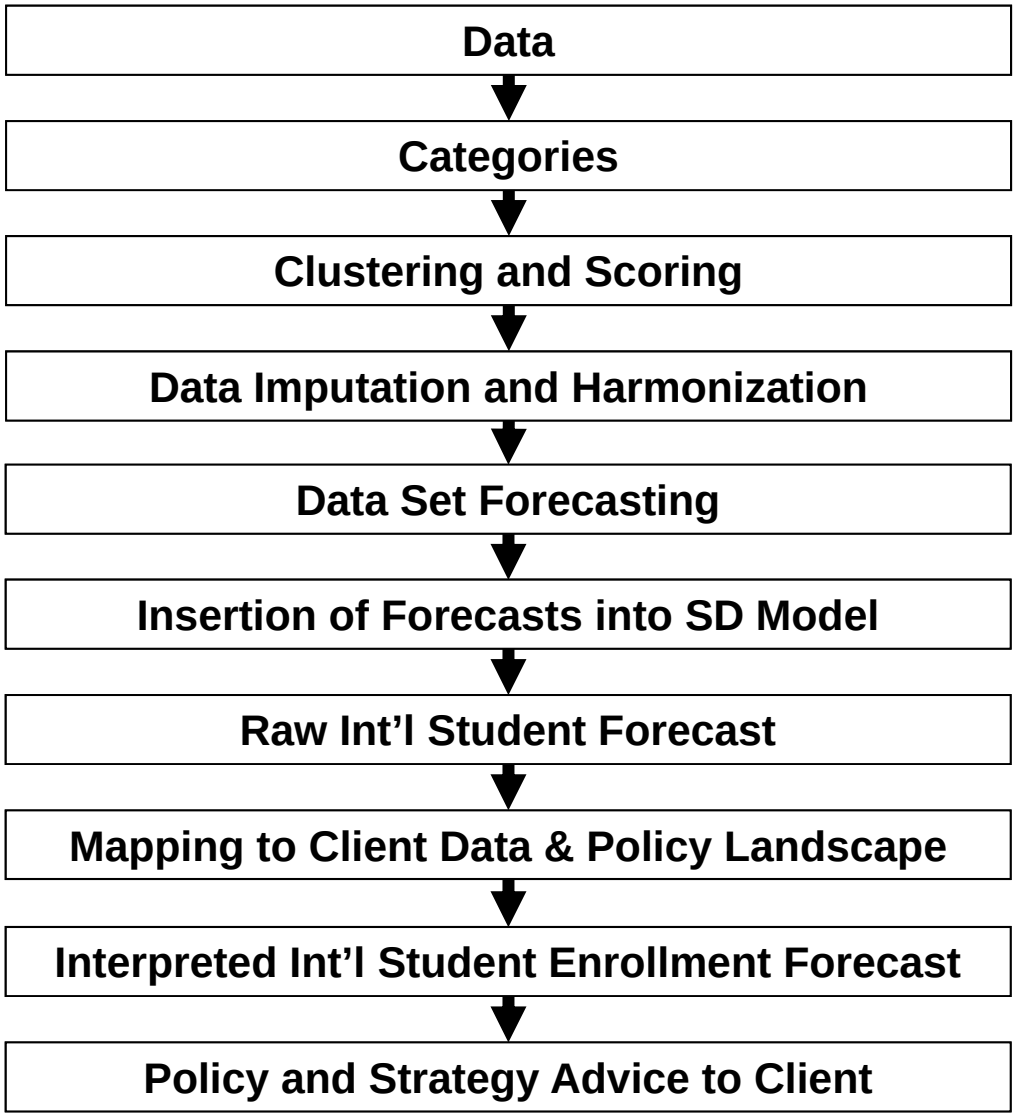
ISAFM assists with managing this dynamic, uncertain landscape

ISAFM OVERVIEW – CORE VISION AND CLIENT SERVICE

- **Core vision**
  - **To create an integrated analysis and forecasting tool which allows for a concise, systematic, evidence-based modeling of international student flows at a national, state/provincial, as well as at an institutional level.**

- **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 HIGH LEVEL OVERVIEW (SCHEMATIC)



ISAFM OVERVIEW – DATA SOURCES

- **ISAFM's underlying data model is built on more than 2.0 million data points.**
- **Data reflects demographic, economic, education, performance, and visa and immigration data from 64 key countries starting in the year 2000.**
- **Many data categories capture data worldwide.**
- **Client data is handled separately from the above data.**
- **Client data confidentiality is safeguarded through a number of measures, including restricted access rules.**

Client data can add many 100,000s of data points

DATA OVERVIEW – INTRODUCTION (I)

- **The basis of ISAFM is an extensive, longitudinal, and granular collection of relevant data which generates, conditions, impacts, and modulates international student movements.**

- **ISAFM is based on five major data categories**

  1) Demographics
  2) Economics
  3) Education
  4) Performance
  5) Visa and immigration

- **Each category captures a range of variables, with total variables captured within the core data model exceeding 120.**

- **Client data is inserted into the core data model. In some instances, such data can exceed 100,000 (student) segments.**

DATA OVERVIEW – INTRODUCTION (II)
Select Variables

Demographics
- 18-year old cohort
- Total population
- Population age 14-24

Economics
- Disposable income
- Gross Domestic Product (GDP)
- Inflation
- Currency rates

Education
- Int'l student enrollment
- Higher education enrollment
- Outbound mobile students

Performance
- IELTS
- TOEFL
- PISA
- Patents
- Innovation rankings

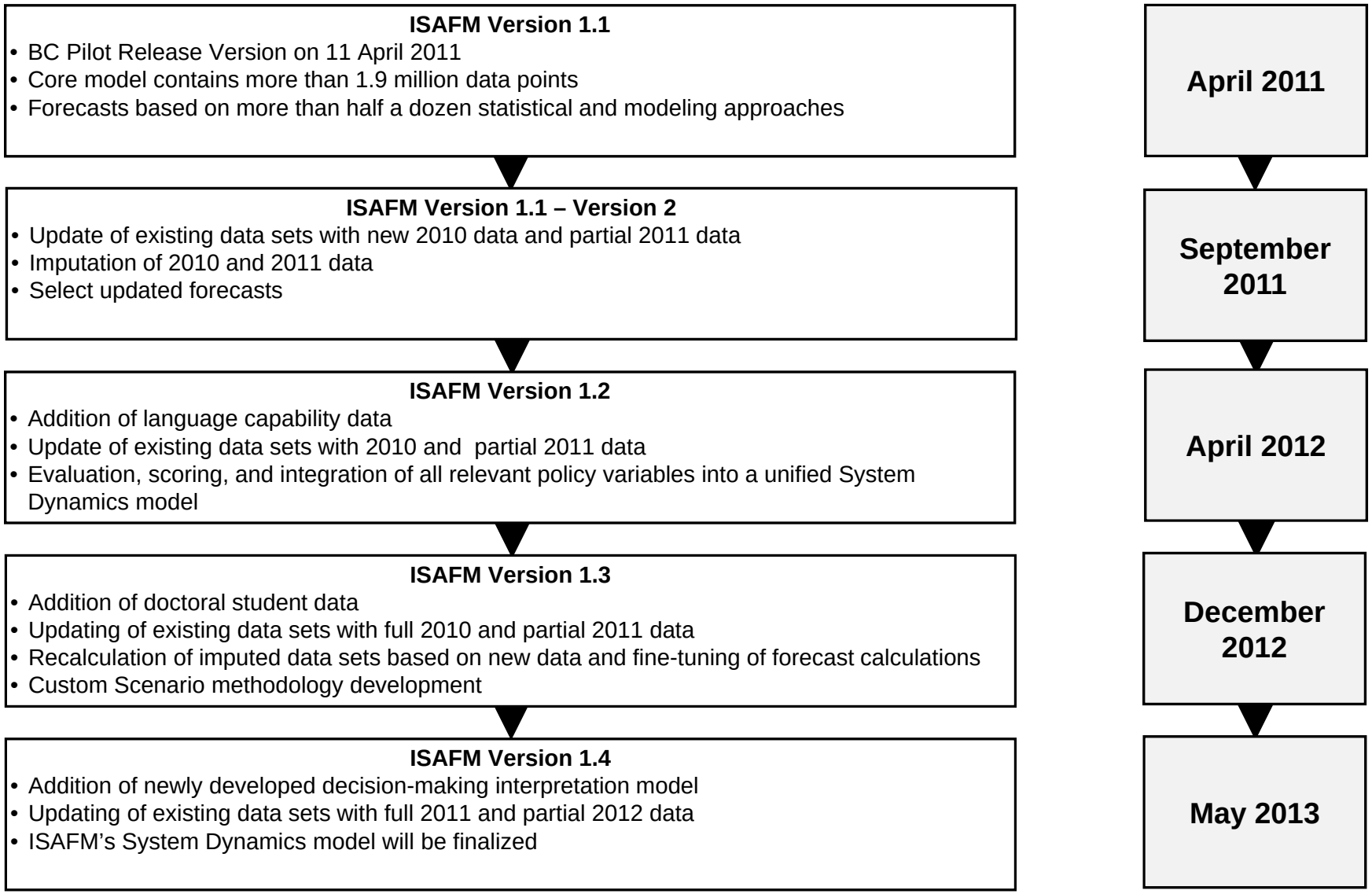
Visa and Immigration
- Visa processing time
- Visa success rate
- Work permit rules

Total variables in ISAFM: 128

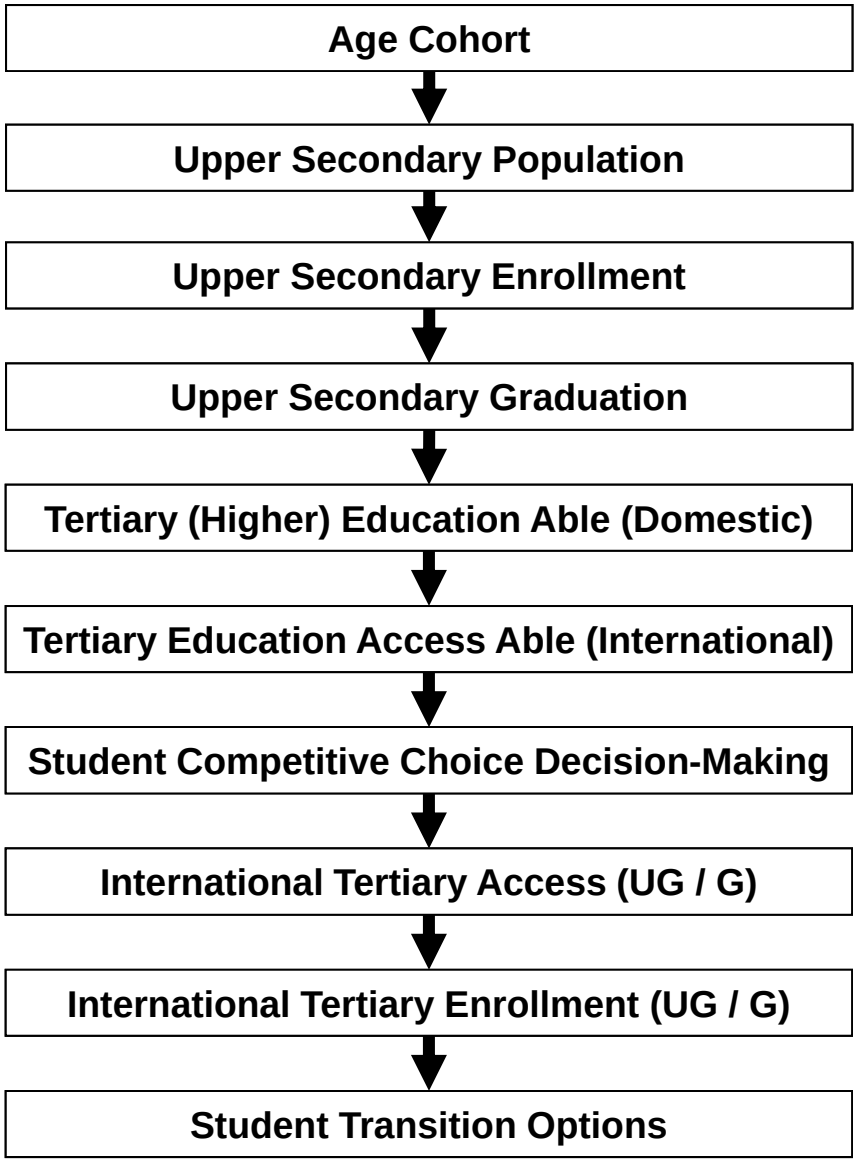
SCENARIOS – INTRODUCTION

- **Introduction to Scenarios**
  - **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 form a crucial part of ISAFM because they allow adjusting for real-life variations to the baseline, system dynamics-generated forecast. Scenarios can cover existing and/or emerging events, or reflect on the likely impact of hypothetical events.**
- **Scenario Calculation**
  - **Scenarios are based on the transformation of qualitative and quantitative data into business rules. These rules are computed in multi-variable regression models in order to achieve the necessary sensitivity to disruptive events.**
- **Scenario Provision**
  - **ISAFM operates on a set of base scenarios. Clients can request custom scenarios.**

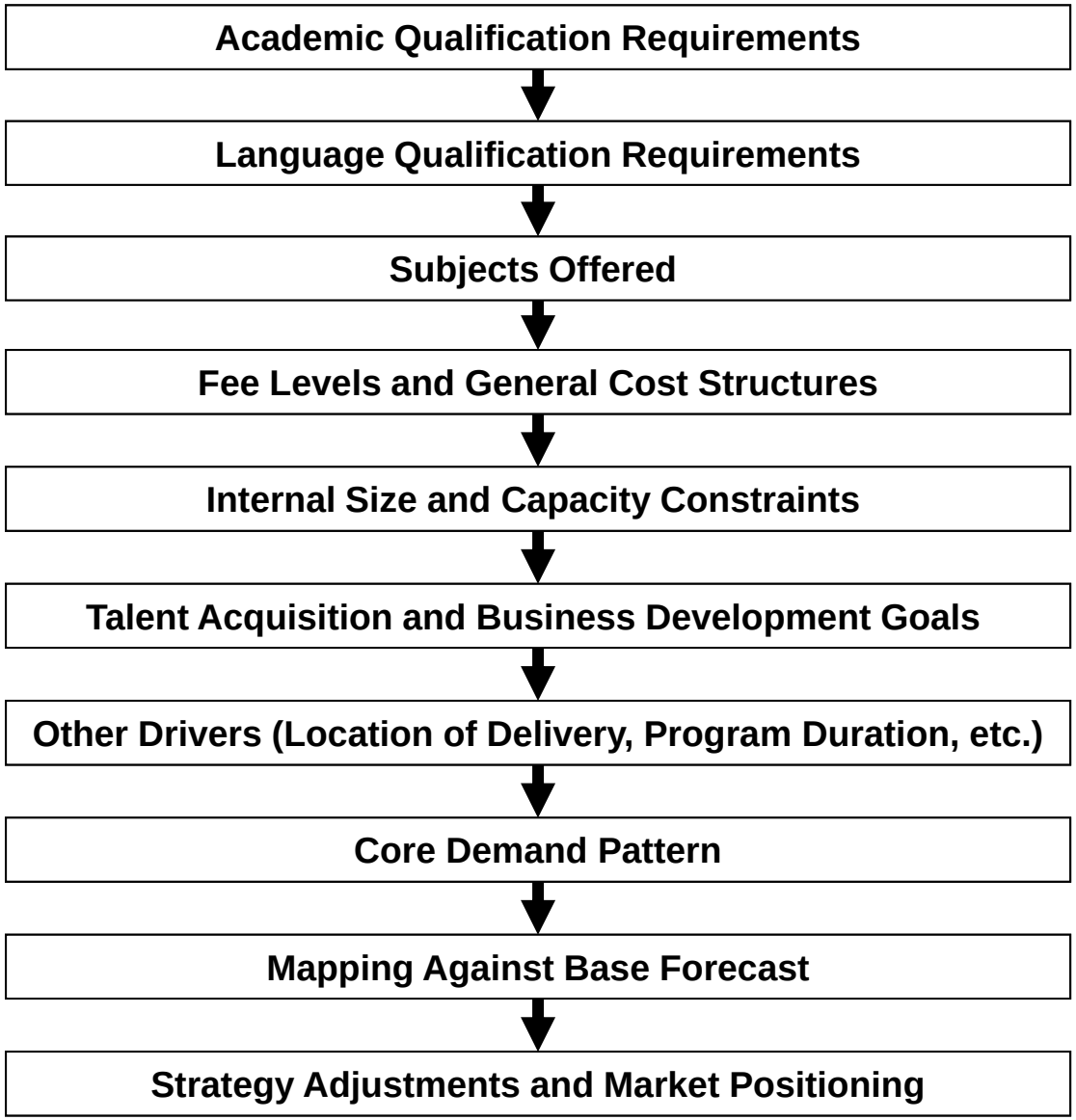
ISAFM DEVELOPMENT STAGE AND FUTURE DEVELOPMENT DIRECTIONS (SCHEMATIC)



STUDENT FLOW MODEL (HIGH LEVEL SCHEMATIC)



NATIONAL/PROVINCIAL/INSTITUTIONAL DEMAND MODEL (HIGH LEVEL VERSION)



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OVERVIEW OF ISAFM METHODOLOGY

- **Multifaceted approach to modeling and forecasting**
  - **Multivariate Regression**
    - **Dynamic Linear Regression**
    - **Panel Data Regression**
  - **Bayesian Analysis – Probabilistic Framework**
  - **System Dynamics**

OVERVIEW OF ISAFM METHODOLOGY

- **The following 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)**

ON FORECASTING

- **Fit statistical models to historic data**
  - **Look-back period of 11 years (rolling)**
- **Estimate relationships between predictor variables and total international student enrollment**
- **Compute predicted values for future total international student enrollment**

ON FORECASTING
Limitations

- **Predictive power of models depends on model accuracy**
  - **Model accuracy depends, in part, on data availability and data quality**
    - **Lack of data**
    - **Incorrect, incomplete, or mis-specified data**
    - **Measurement units (“one” international student)**
- **Regression analysis shows correlation rather than causation**

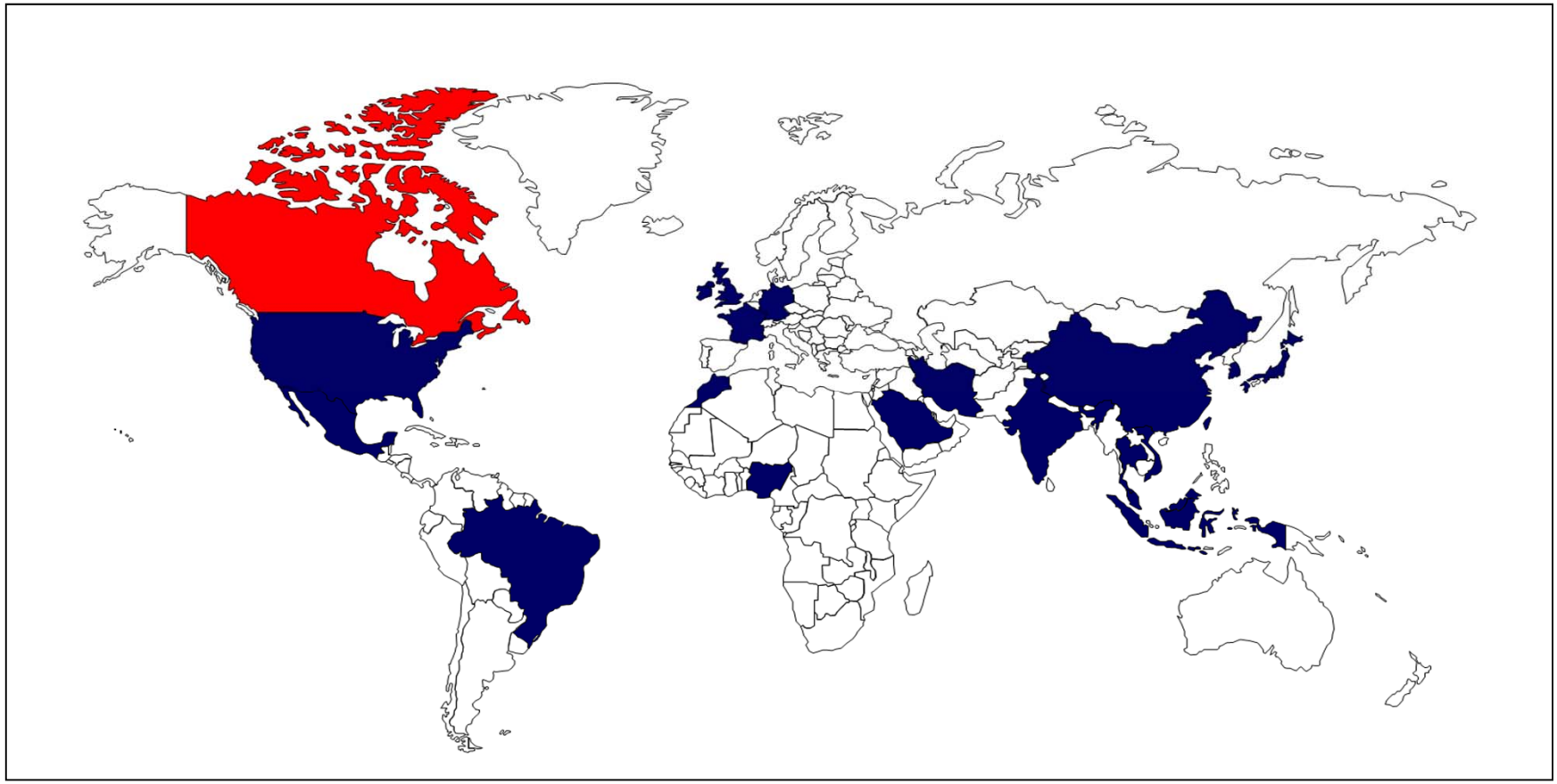
KEY CHALLENGES AND BROAD MODEL GROUPS

- **Key challenge for ISAFM: Model differences between countries, and the dynamic nature of the process, to provide reliable and useful results.**
- **ISAFM captures the variability in enrollments over time, but also the variability between countries, in a simple, yet not simplistic, framework.**
- **ISAFM employs several modeling methods, which are classified into two broad groups: “Push” and “Pull” models of enrollment.**

PUSH AND PULL MODELS (I)

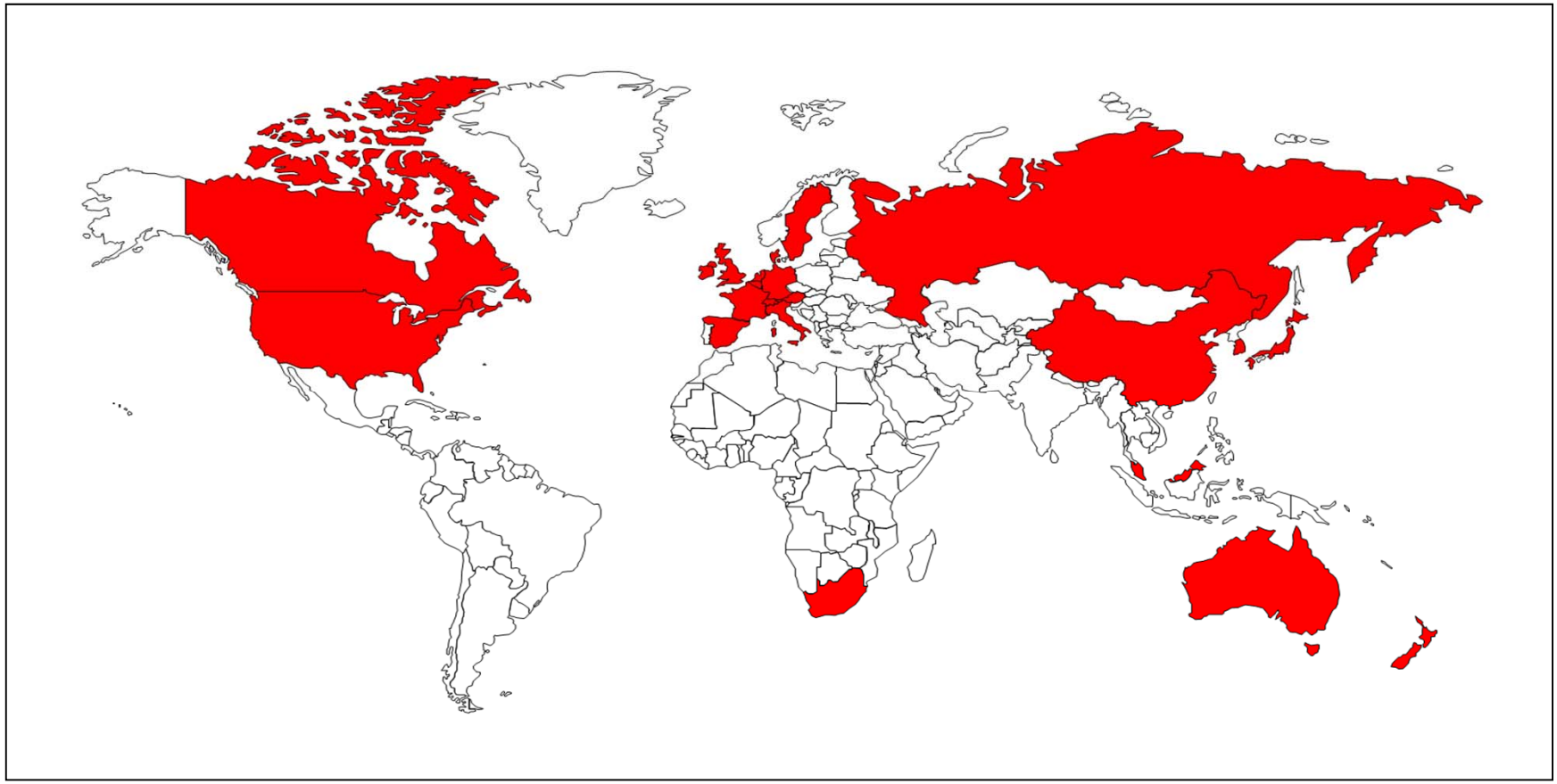
- Several types of time series and panel data regression techniques were used to fit these models and generate the forecasts.
- The statistical analysis was derived from a theoretical model of international enrollments developed by the modeling team.
- The key assumption to these models is that the variation in the demographic, economic, education, performance, and visa and immigration variables can be used to predict variation in enrollments.
- Fitting a wide variety of models to ensure that results were robust to the specification of the statistical model.
- Modeling outbound student mobility alongside international enrollments and distinguish how “push” and “pull” factors separately influence enrollments.

PUSH AND PULL MODELS (II)
ISAFM Push Model of International Enrollment



Top 23 receiving countries were included in the push model

PULL AND PULL MODELS (III)
ISAFM Pull Model of International Enrollment



Top 20 receiving countries were included in the pull model

SYSTEM DYNAMICS
Modeling Complex Real-World Systems

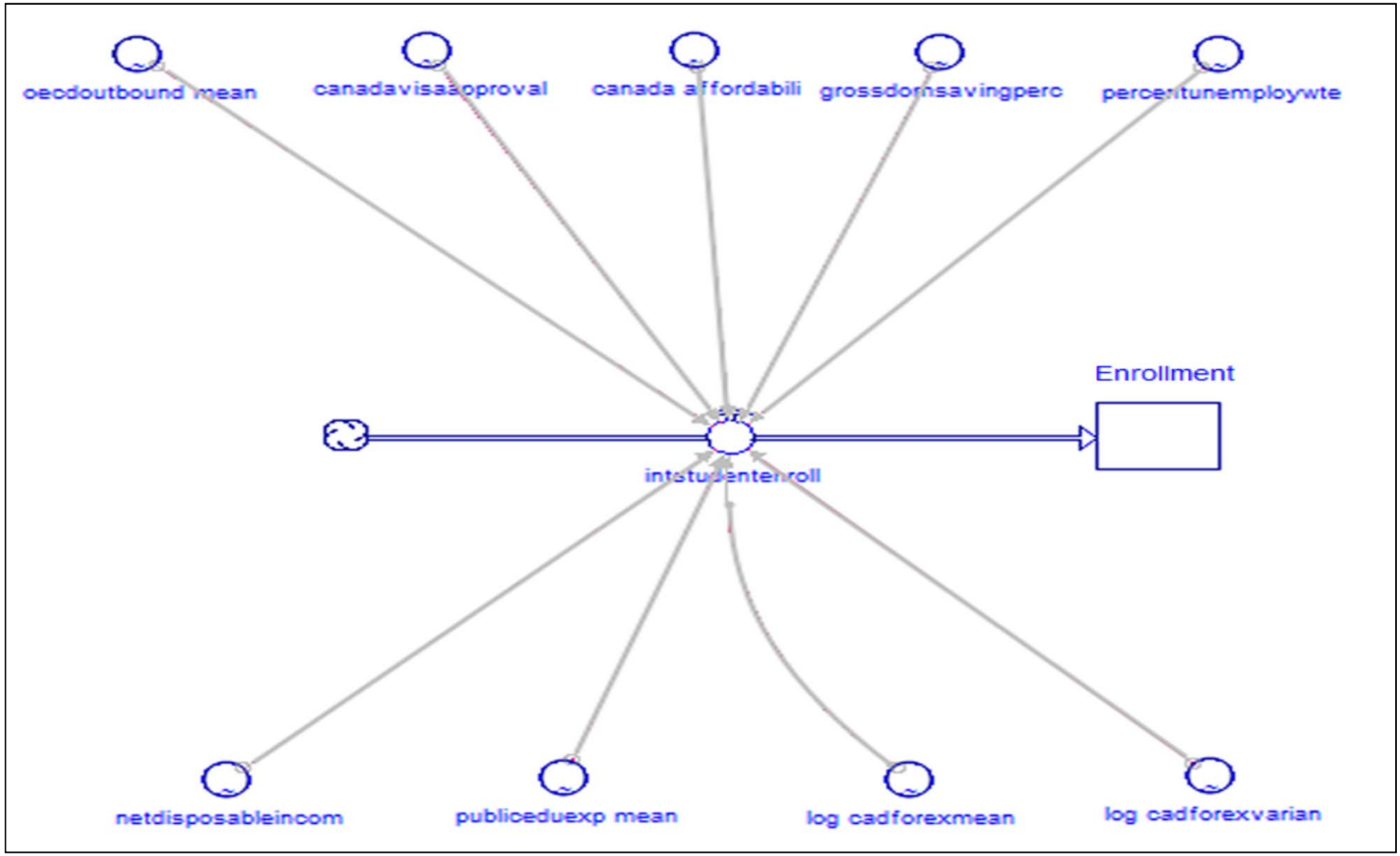
- **System Dynamics allows us to model interactions between elements of a complex system and reproduce its dynamic behavior.**

- **International student mobility: heterogeneous factors affecting the process are very challenging to characterize. Political, economic, historical and cultural considerations can be merged within the System Dynamics framework.**

- **System Dynamics is not an alternative to statistical modeling techniques. It complements them by incorporating additional variables calibrated, for instance, by specialists in the field.**

  "*To omit such variables is equivalent to saying they have zero effect, probably the only value that is known to be wrong." (Forrester, J. W. "Industrial Dynamics" 1961.)*

SYSTEM DYNAMICS
Basic Supply Flow Model



SYSTEM DYNAMICS
Modeling Complex Real-World Systems

- **The System Dynamics Model's causal effects were captured by a linear function with coefficients calculated by least squares fitting.**
- **The Model can incorporate more sophisticated functions. Several machine learning techniques were implemented and evaluated for this purpose.**
- **Testing is an integral part of the System Dynamics modeling process.**
- **An interface for sensitivity analysis was implemented in Stella and used to perform sensitivity analyses of the independent variables for each of the source countries.**

SYSTEM DYNAMICS
Future Model Development

- **Further development steps include**
  - **Incorporating boundary constraints to enforce natural capacity limits for destination countries.**
  - **Combining statistical analysis and input from experts to quantify the interaction of relevant variables.**
  - **Further tests under a wide range of conditions.**
  - **Developing and calibrating a system dynamics model must be a joint effort involving careful quantitative analysis, exhaustive simulations and evaluations by experts.**

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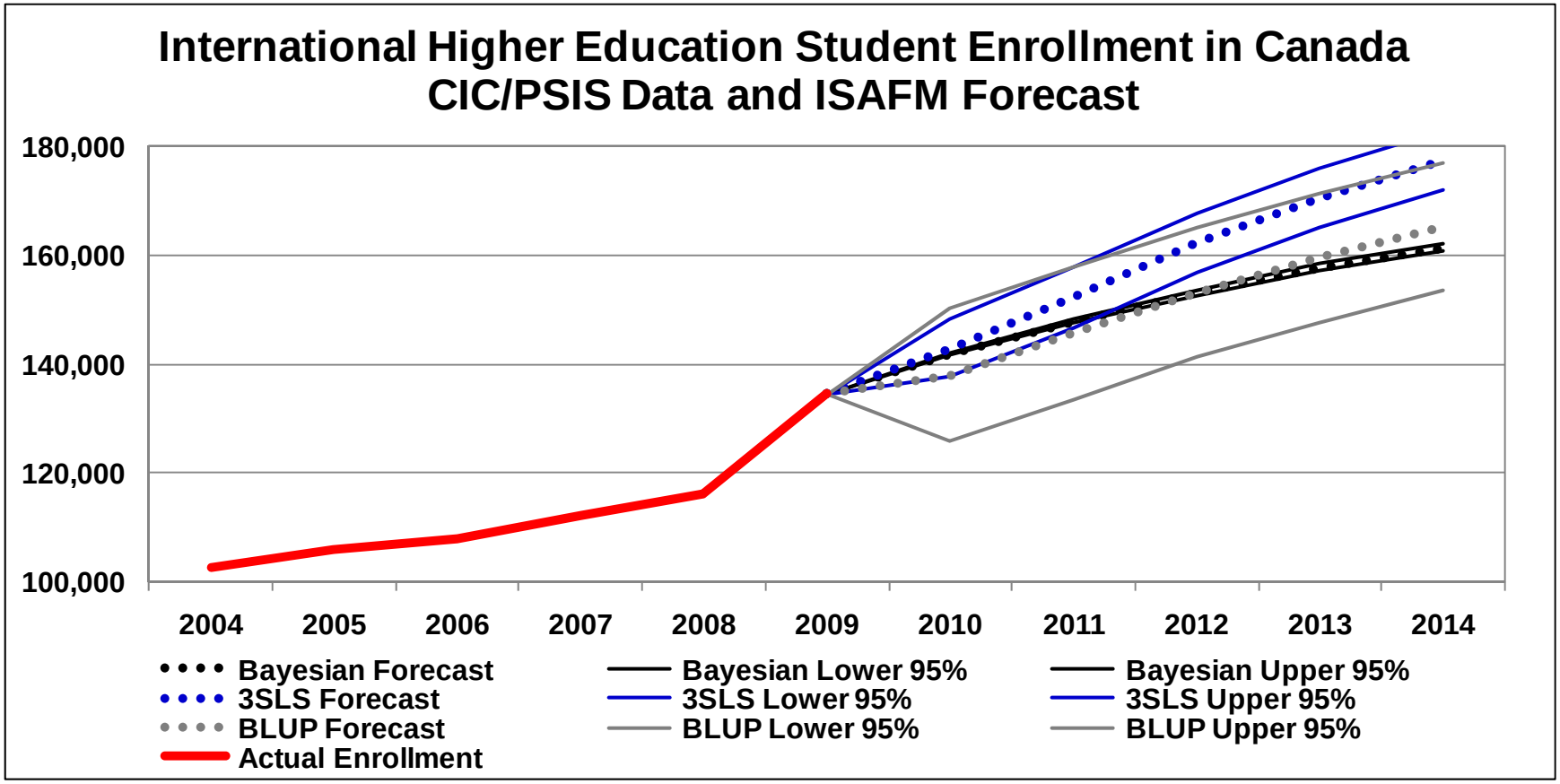
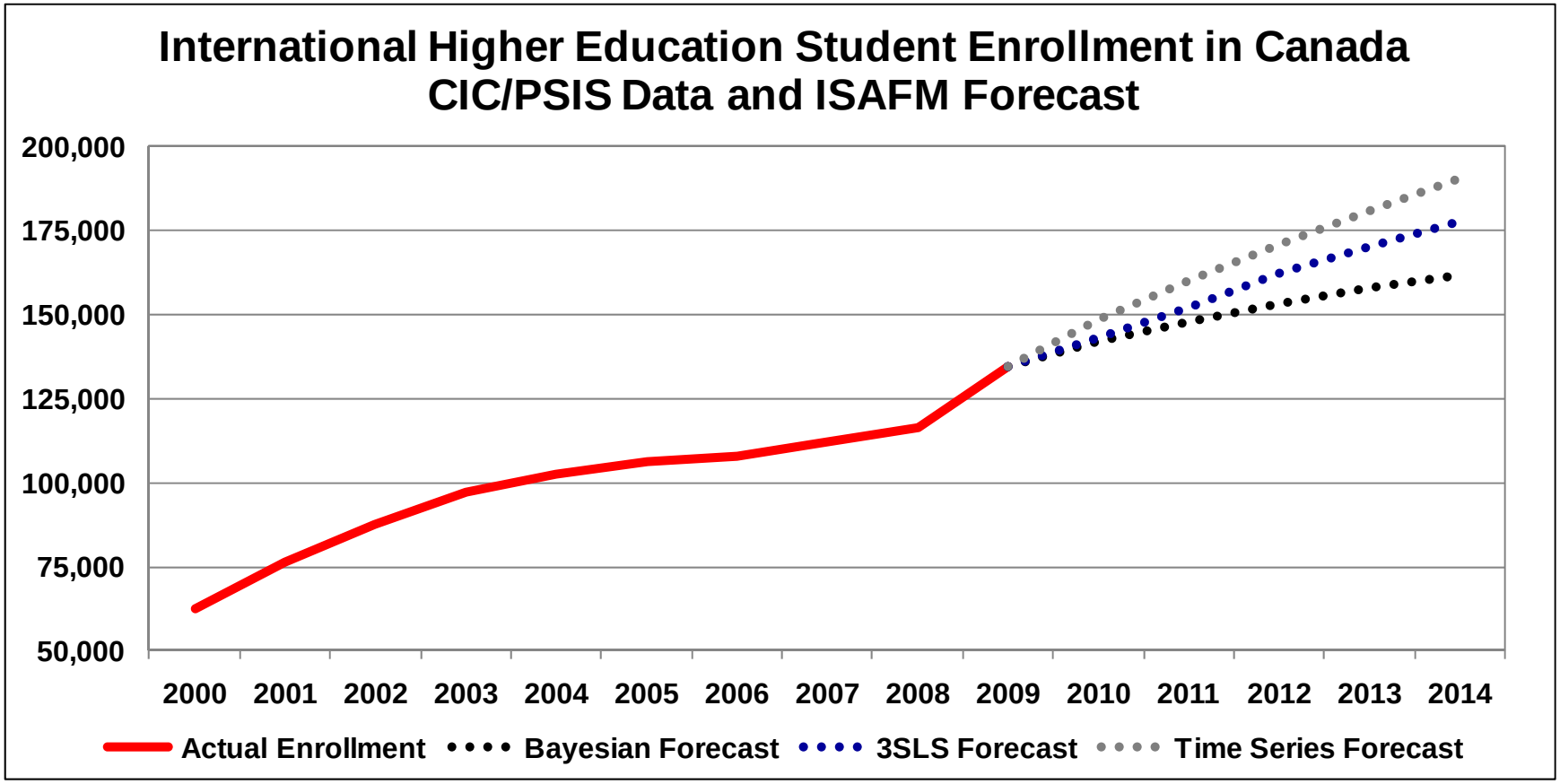
ISAFM FORECAST V1.1 - CANADA
95% Confidence Intervals



A story of models, ranges, and 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.

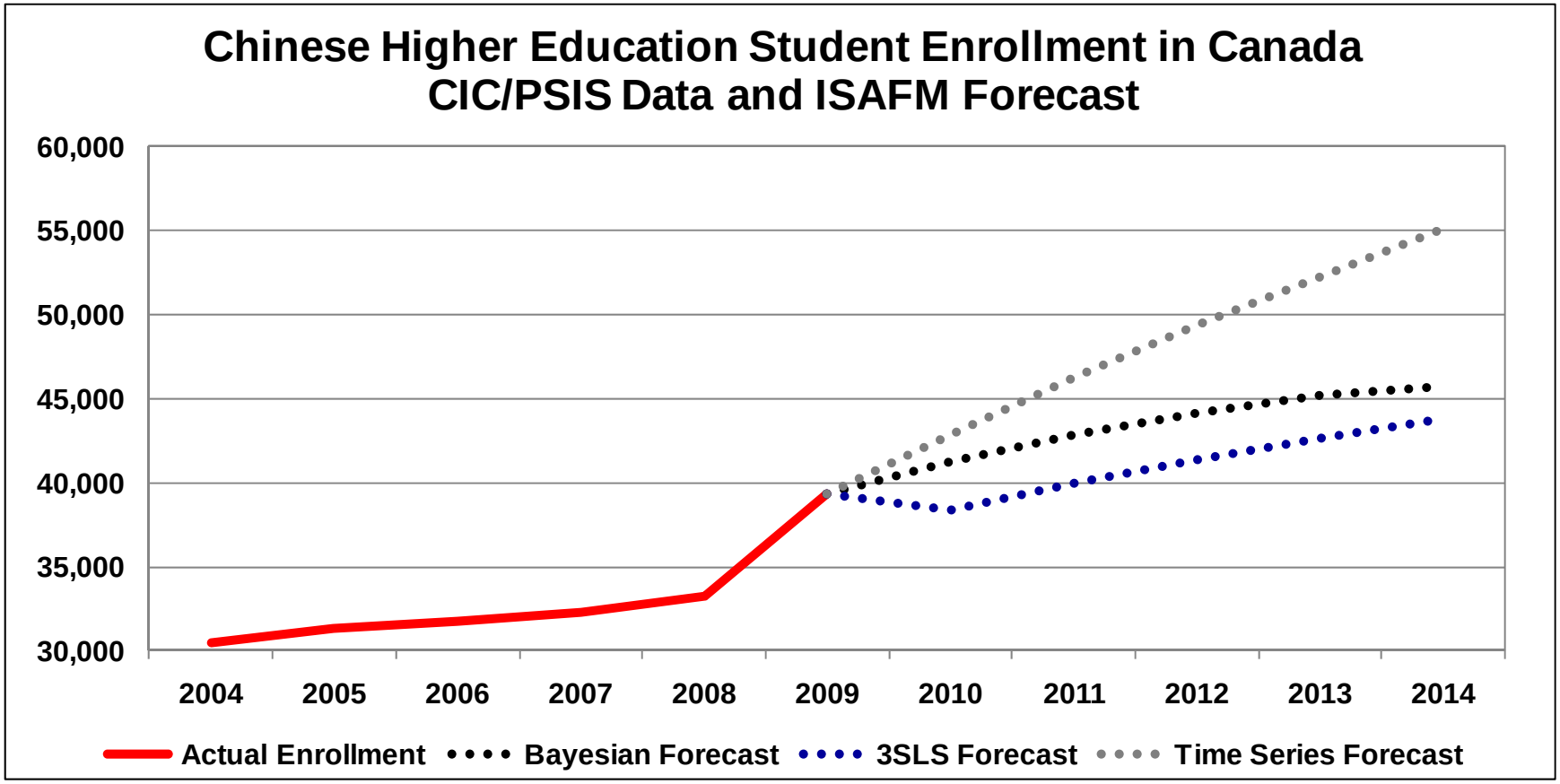
ISAFM FORECAST V1.1 - CANADA
Total International Higher Education Student Enrollment



Key perspective: Further growth

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.

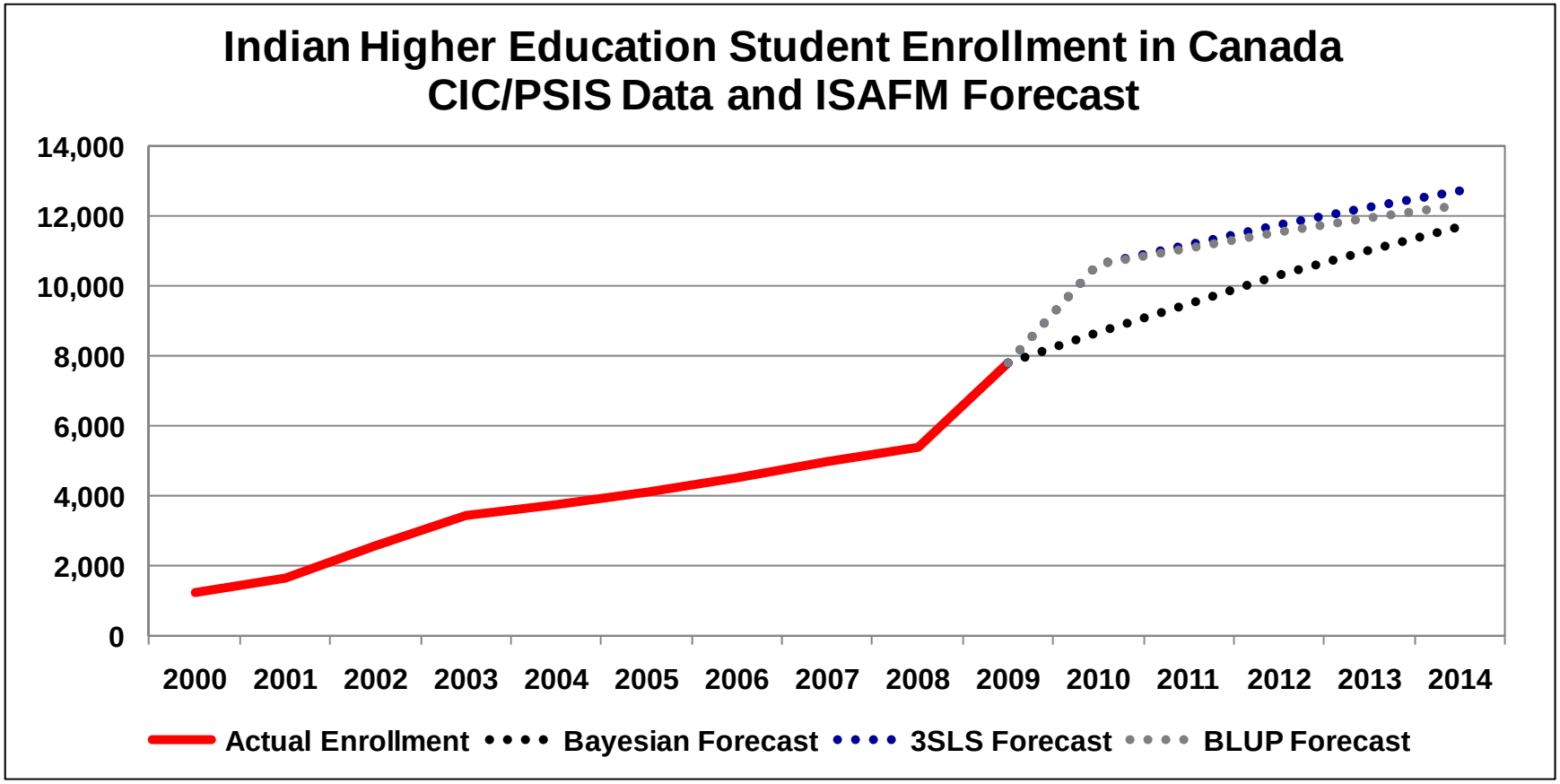
ISAFM FORECAST V1.1 - CANADA
Chinese Higher Education Student Enrollment



Key perspective: Further growth, but big warning signs

Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares. Actual enrollment for 2000 through 2003 were excluded for illustration purposes.
Sources: CIC, PSIS, ISAFM.

ISAFM FORECAST V1.1 - CANADA
Indian Higher Education Student Enrollment



Key perspective: Further growth, but a not a reflection of overall trends

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.

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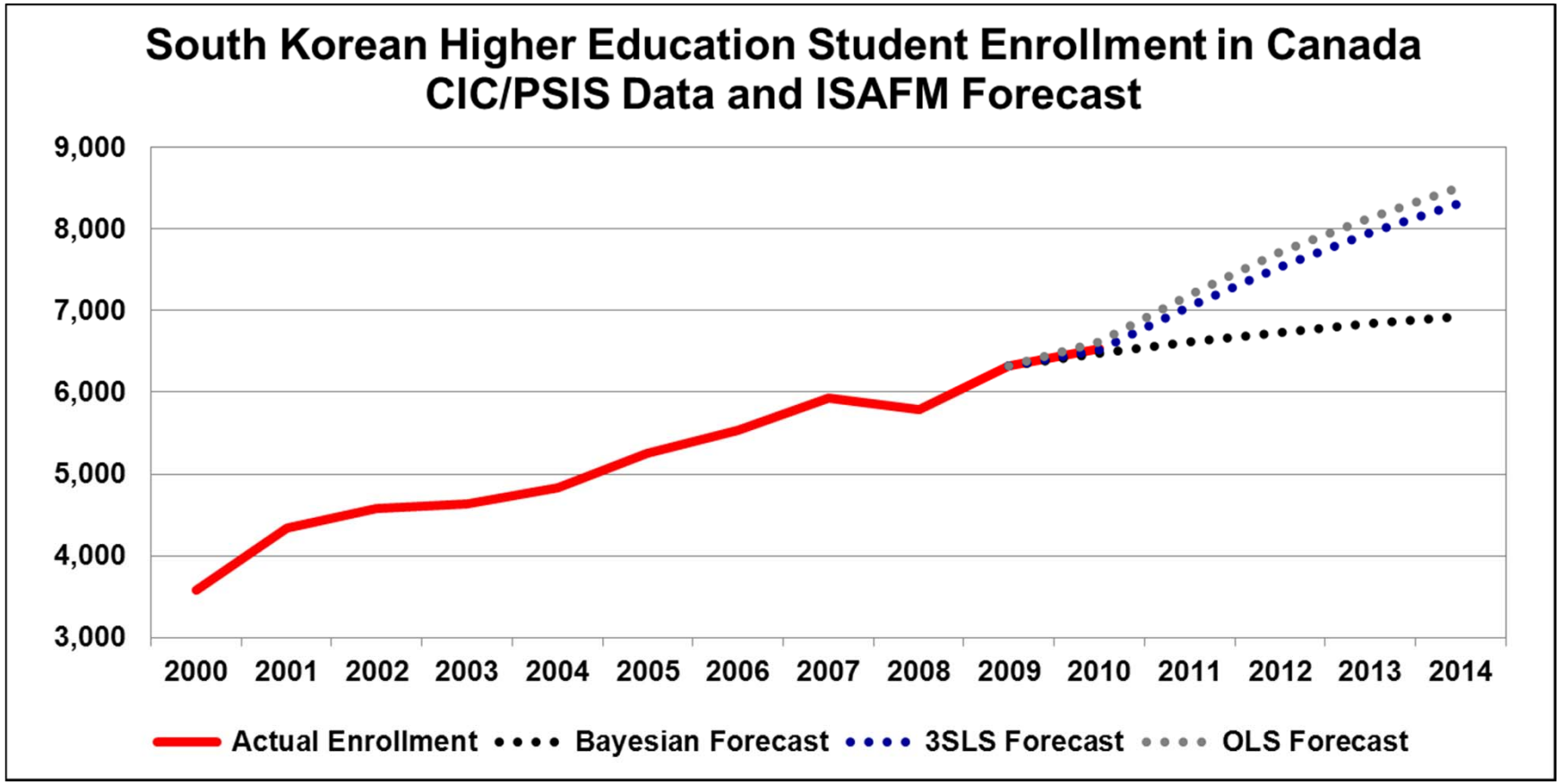
ISAFM FORECAST V1.1-2 - CANADA
South Korean Higher Education Student Enrollment



ISAFM V1.1 forecast was highly accurate

Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
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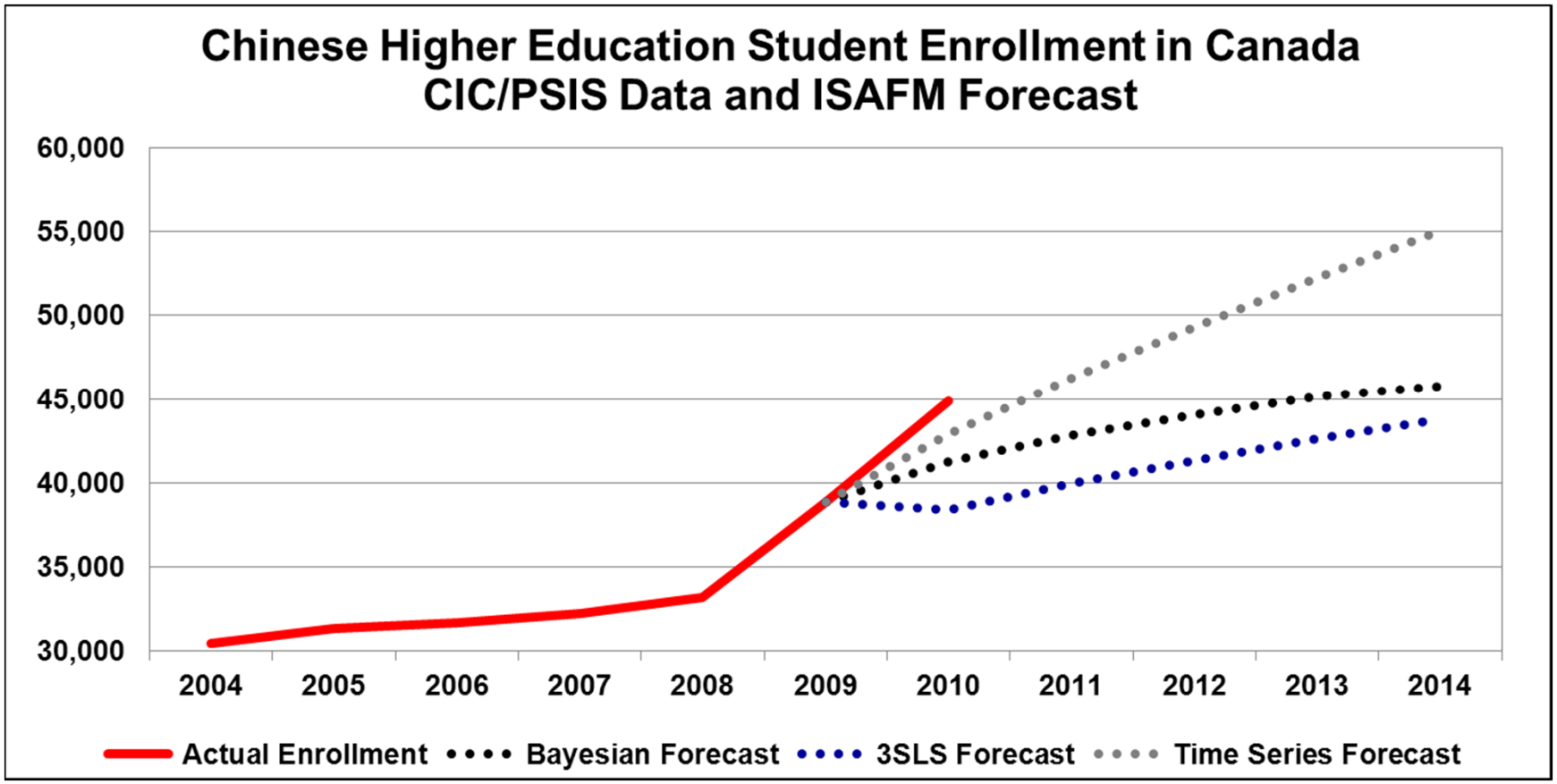
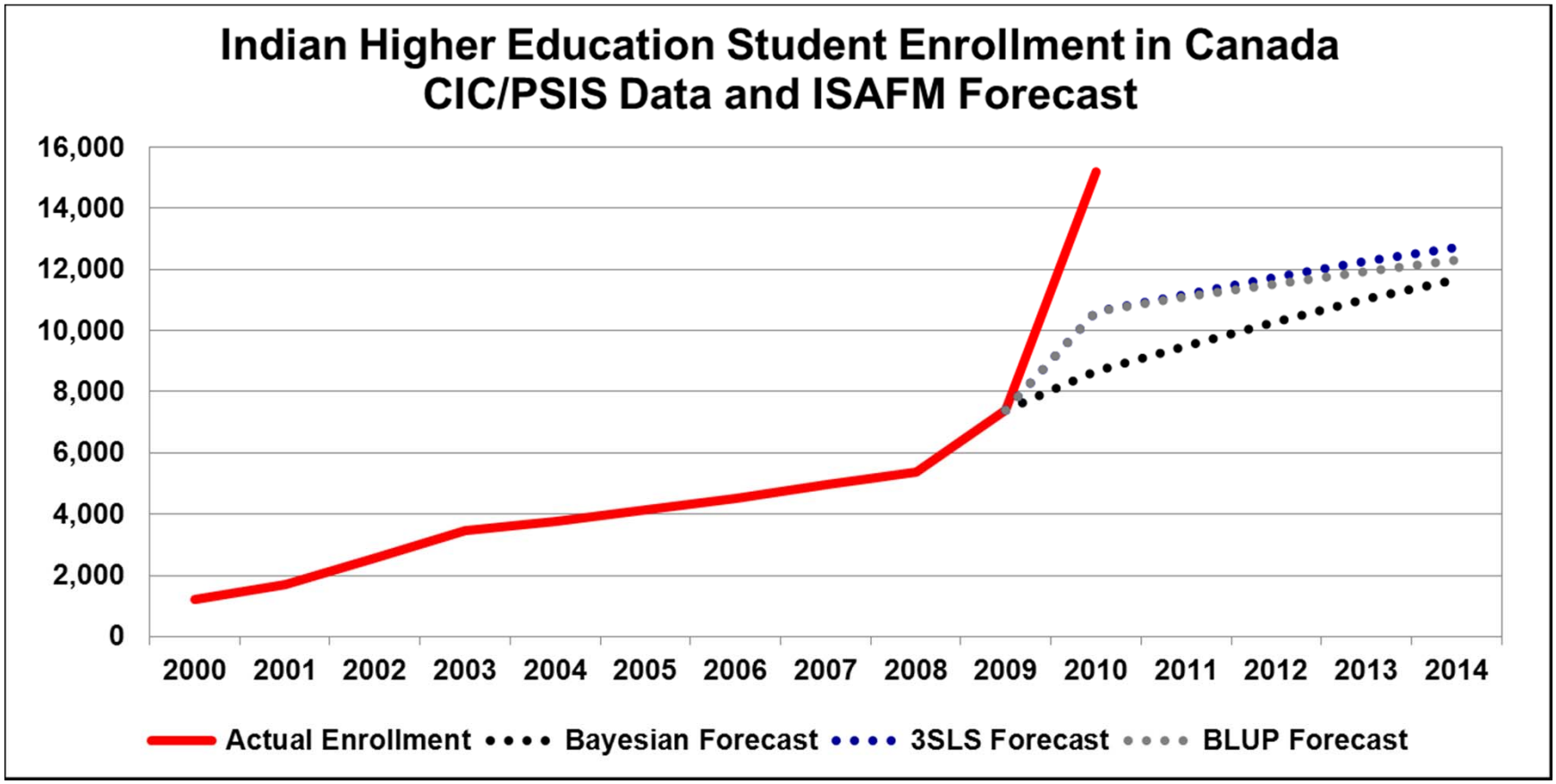
ISAFM FORECAST V1.1-2 - CANADA
Chinese Higher Education Student Enrollment



ISAFM V1.1 TSF forecast was accurate – strong growth discount issue

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.

ISAFM FORECAST V1.1-2 - CANADA
Indian Higher Education Student Enrollment



ISAFM V1.1 forecast was purposefully geared to normative long-term approach

Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
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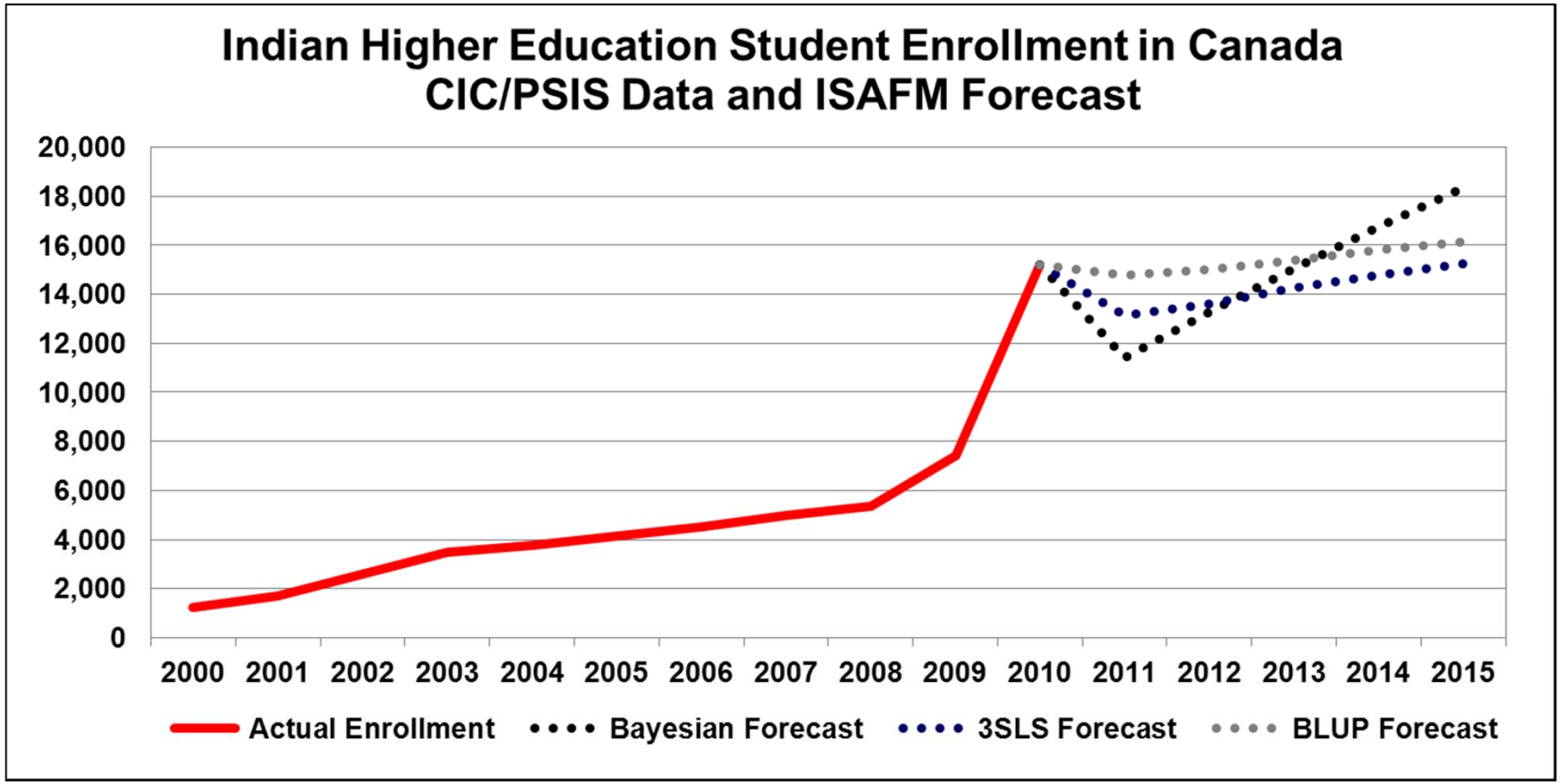
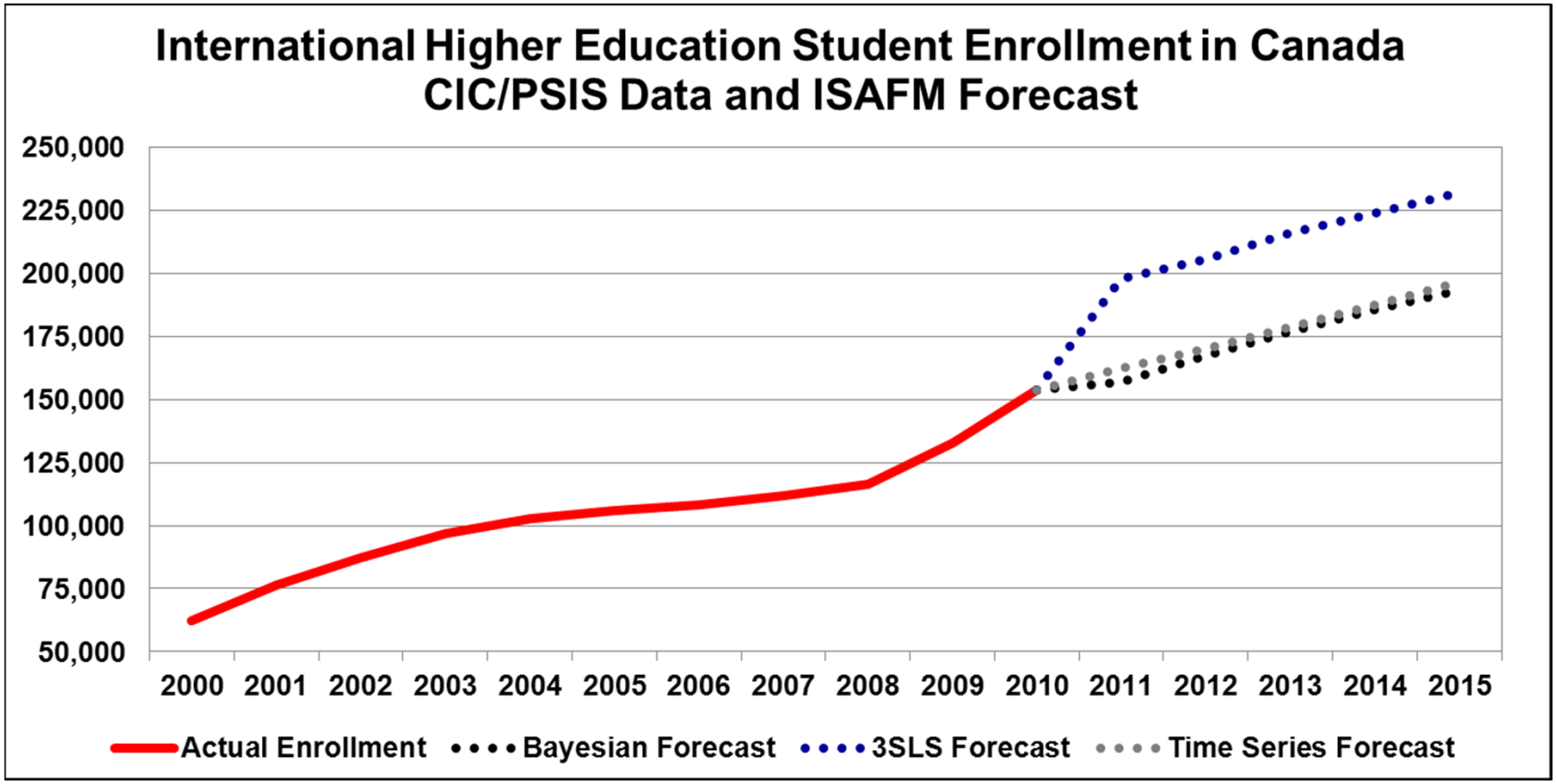
ISAFM FORECAST V1.1-2 - CANADA
Indian Higher Education Student Enrollment



ISAFM V1.1-2 corrects for hyper growth

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.

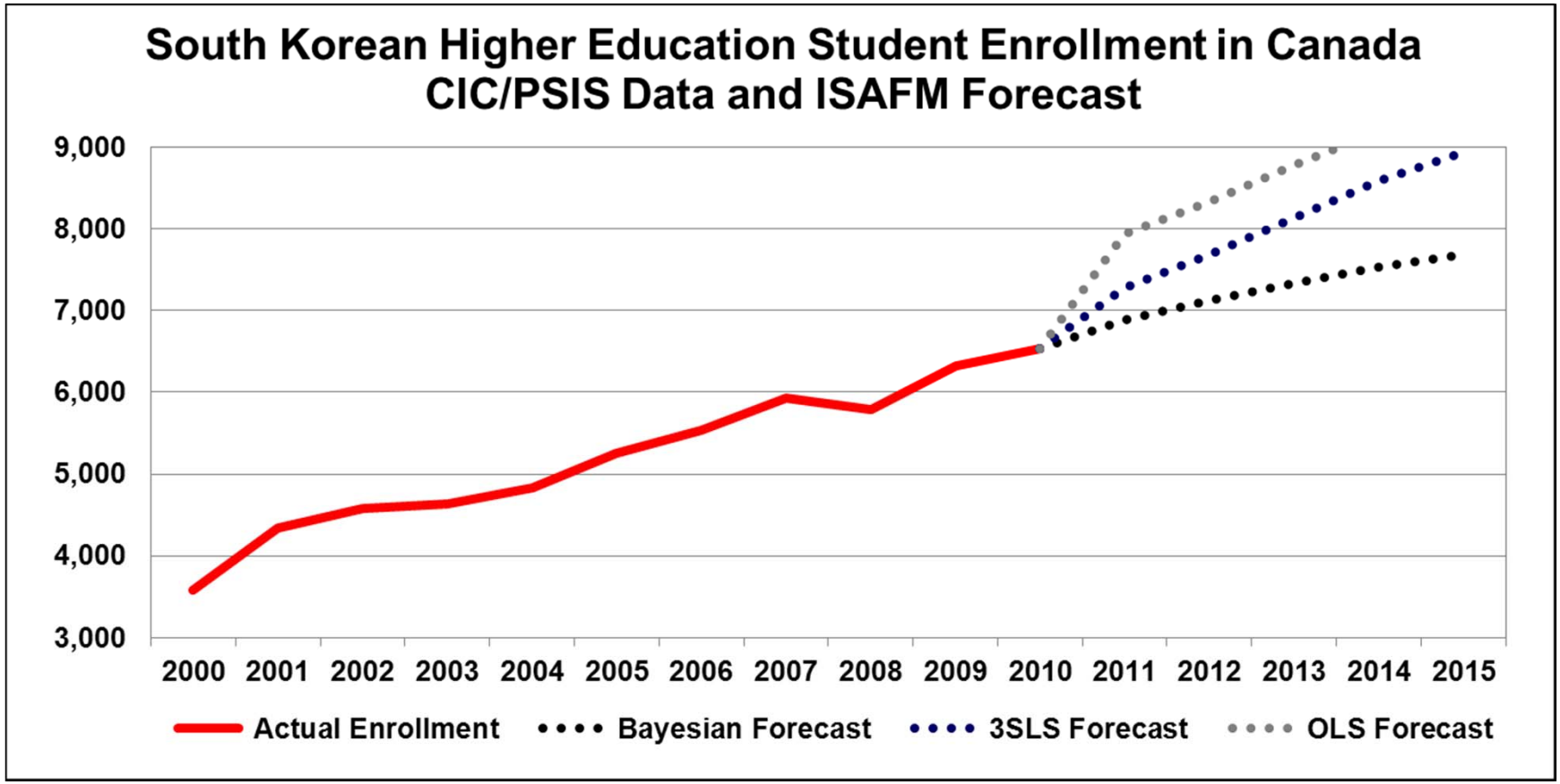
ISAFM FORECAST V1.1-2 - CANADA
Total International Higher Education Student Enrollment



ISAFM V1.1-2 forecast 3SLS appears best model

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.

ISAFM FORECAST V1.1-2 - CANADA
South Korean Higher Education Student Enrollment



ISAFM V1.1-2 forecasts steady growth

Notes: Actual enrollment data are based on both CIC total enrollments ("University" and "Other Post-Secondary" segments) and PSIS enrollment shares.
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INSTITUTIONAL PERSPECTIVES ON ENROLLMENT FORECASTING
BCCIE and Okanagan College

Comments from BCCIE and Okanagan go here.

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