Forecasting University Funding: A Non-Linear Approach

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Abstract

Are enrollment-based funding formulas really dependent on enrollment? The recent changes in funding for universities in the province of Quebec, Canada, suggests a disconnect between subsidies and enrollment despite the funding being enrollment based. This disconnection is observed when using a linear model to forecast the funding of the different universities in Quebec. The results show that simply considering linear mechanisms in the models consistently underestimates the funding. This paper explores the importance of taking into consideration these non-linear mechanisms in the funding formula. We estimate the funding models with non-linear vector autoregressive and the margins of error with bootstrap methods. This allows us to directly estimate the funding formula, and thus the non-linear components. We find that the non-linearities are important to explain the funding trends. In particular, the smoothing mechanism, the increase in funding per student and other exceptions leads subsidies to increase despite a stagnation or a decline in enrollment. Moreover, the model developed in this article also provides a ready-made recipe for forecasts in other jurisdictions.

Keywords: universities, enrollment, funding formula, forecast, non-linear vector autoregressive, higher education

1. Introduction

Many universities receive a significant part of their funding through government subsidies. The procedural rules through which the public sector determines subsidies is often dubbed a "funding formula" (Bouchard St-Amant, Brabant & Germain, 2020; Bouchard St-Amant et al. 2022a; Hillman & Peek 2023; Laderman et al. 2023). Most formulas depend on a combination of inputs, outputs, fixed allocations, or conditions (see Jongbloed 2023; Bouchard St-Amant & Goyette-Levac 2022; Bouchard St-Amant et al. 2022b; Bouchard St-Amant et al. 2023 for detailed examples). Understanding how these subsidies evolve is of crucial importance for planning, but also for practical measuring of whether the intent stated in a formula is actually connected to the subsidy received.

This article has three scientific contributions. First, it uses the detailed knowledge of a funding formula to build a novel forecasting methodology. It incorporates non-linear vector-autoregressive models (VARs) and bootstrapping methods, which improves the forecasting accuracy of our previous work (Bouchard St-Amant et al., 2020). VAR models are widely used to predict the evolution of variables based on their past values and the past values of other variables. This idea of the time-dependence paradigm is used in this article, but we contribute by incorporating non-linear specificities of the funding formula. While keeping the same set of variables, we change the modelling technique and improve the forecasting accuracy. More precisely, we estimate the actual funding formula, which allows us to directly consider the non-linear mechanisms.

Second, our findings underpin the importance of looking seriously at the specificities that yield the non-linearities in the actual funding formula because they weaken the normative connection between the criteria used in the formula and the actual subsidy. When considered, these "details" weaken the underlying justifying principle. From a normative standpoint, it may be grounds for either softening the consequences of a particularly unwanted narrative or, to the contrary, for criticizing a formula for its lack of coherence. In the case of the enrollment-dependent formula studied, the increase in subsidies per student, combined with smoothing mechanisms when enrollment declines, leads to an increase in subsidies, although there is a decline in enrollment.

Our third and perhaps most obvious contribution is to improve forecasts by applying the methodology to eighteen universities. The article thus provides new forecasting techniques, helps in understanding the normative implications of a detailed formula (see section 2.2), and has a ready-to-apply, practical tool that universities or government administrations can use for forecasting.

Empirical analyses are bound to a dataset and, thus, to a jurisdiction. As in our previous work, we use the province of Quebec, Canada, where the eighteen universities are highly subsidized through a predominantly enrollment-based formula. Student enrollment numbers are a fundamental component of input-based funding. Therefore, predicting the evolution of student numbers is crucial for anticipating the financial resources the government will need to subsidize universities. (Note 1) However, several specificities related to cost control and funding stability disconnect funding from enrollment, making it somewhat closer to a fixed funding formula. The forecasts therein are specific to Québec, but previous qualitative works done on other jurisdictions suggest that having a deep look at those details may yield similar conclusions in other jurisdictions. Verifying this statement empirically in other jurisdictions would be a welcome line of research.

1.1 Does it Matter?

We present in Tables 1 and 2 the forecasts of student enrollment and funding based on our previous work (see Bouchard St-Amant et al. (2020) for the detail methodology). (Note 2) Those are fourth year forecasts realized in years 2018-2019 to 2021-2022 (for Full-Time Equivalent University Student Enrollment) and 2020-2021 to 2023-2024 (for University Operating Grants). We compare them with realized values, focusing on McGill University, Université Laval, and Université du Québec à Chicoutimi. (Note 3) Although linear models tend to accurately capture the evolution of enrollment (Table 1), they fail to accurately predict the awarded subsidy (Table 2). For McGill University, this translates into a forecasting error on subsidies between 24 to 59 million (5 to 15 percent).

This means that even if the formula is, at its core, constructed based on enrollment, some aspects are not accurately reproduced in a linear model. As we shall see, this lack of accuracy has increased in recent years, precisely because the non-linear aspects of the formula kicked in. Specifically, the increase of funding per student, increasing the overall yearly subsidy, and minimal funding protection mechanisms that are aimed at protecting universities from too important decreases in enrollment, disconnect the subsidies from the enrollment data. This explains why the linear VARs underestimate the subsidy and why some universities' funding is no longer connected to enrollment. The VARs models previously developed in Bouchard St-Amant et al. (2020) only considered linear relationships between funding and enrollment. However, the actual funding formula is inherently non-linear in funding and enrollment. As these non-linear mechanisms become more important in determining the actual funding, the forecasts can differ considerably from the actual values.

The disconnection between enrollment and funding is particularly well represented by the linear forecast for Concordia University. Figure 1 presents the enrollment and funding forecast for the linear VARs models developed in Bouchard St-Amant et al. (2020). We observe a drop in enrollment accompanied by an increase in funding for the real values. However, Figure 1 also shows that the linear model underestimates the funding as it follows the trends in enrollment. This results in a considerable difference between the real and forecast values of the funding. The model developed in the following sections addresses this issue and improves considerably the forecasts (see Figure 3).

Table 1. Forecasts and Actual Values of Full-Time Equivalent University Student Enrollment

University	Academic Year	95% Margin of Confidence	Actual Enrollment	Forecasted Enrollment
McGill	2018-2019	[22.93 ; 27.26]	26.40	25.09
	2019-2020	[24.50 ; 28.99]	26.37	26.75
	2020-2021	[18.91 ; 32.19]	27.65	25.55
	2021-2022	[25.65 ; 29.07]	27.25	27.36
Laval	2018-2019	[32.37 ; 33.04]	32.95	32.71
	2019-2020	[32.75 ; 33.49]	32.72*	33.12
	2020-2021	[34.49 ; 36.14]	35.25	35.31
	2021-2022	[35.11 ; 36.45]	34.92*	35.78
UQAC	2018-2019	[4.95 ; 5.06]	4.47*	5.00
	2019-2020	[4.87 ; 5.00]	4.23*	4.94
	2020-2021	[4.81 ; 5.05]	3.93*	4.93
	2021-2022	[3.92 ; 4.45]	4.05	4.19

Notes: The enrollment figures are in thousands of FTE, so 23.76 is actually 23,760 full-time equivalent students, etc.

Source: Author’s calculations based on Bouchard St-Amant et al. (2020) and Ministère de l’Enseignement supérieur (2024a).

Table 2. Forecasts and Actual Values of University Operating Grants (CAD, Millions)

University	Year	95% Margin of Confidence	Actual Subsidy	Forecasted Subsidy
McGill	2020-2021	[317.73 ; 373.31]	403.78*	345.52
	2021-2022	[347.86 ; 397.62]	414.00*	372.74
	2022-2023	[290.54 ; 482.71]	436.32	386.63
	2023-2024	[450.24 ; 505.74]	454.44	477.99
Laval	2020-2021	[441.06 ; 472.48]	472.73*	456.77
	2021-2022	[451.99 ; 483.50]	508.03*	467.74
	2022-2023	[451.99 ; 539.59]	546.54*	481.83
	2023-2024	[566.15 ; 629.94]	563.49*	598.05
UQAC	2020-2021	[80.66 ; 88.29]	87.03	84.48
	2021-2022	[82.49 ; 90.29]	96.93*	86.39
	2022-2023	[79.11 ; 98.80]	97.66	89.00
	2023-2024	[88.69 ; 101.72]	100.57	95.20

Source: Author’s calculations based on Bouchard St-Amant et al. (2020) and Ministère de l’Enseignement supérieur(2024a).

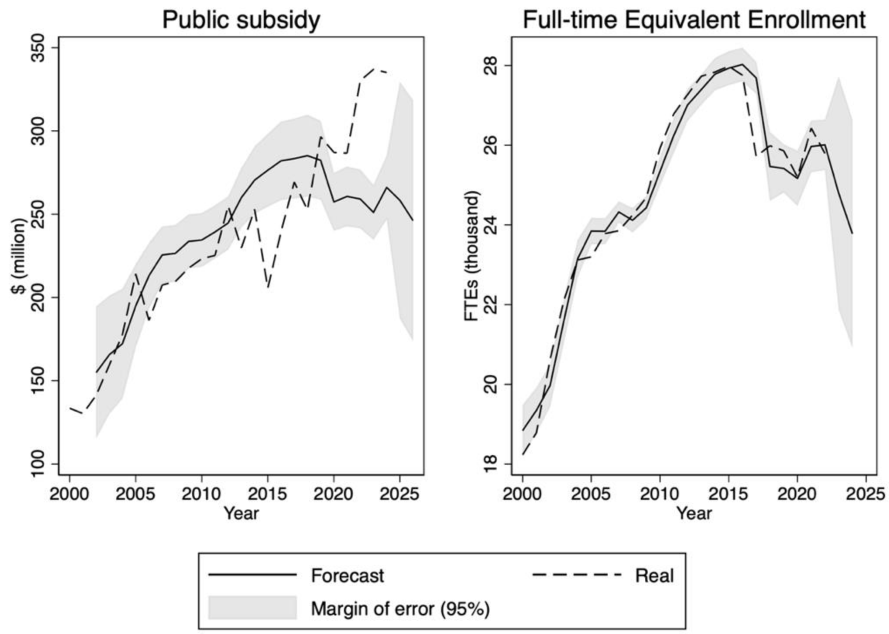

Figure 1. Concordia University forecasts with VARs linear model (Bouchard St-Amant et al., 2020)

Source: Author's calculations based on Bouchard St-Amant et al. (2020) and Ministère de l'Enseignement supérieur (2024a).

The motivation for this article arises from the inherent limitations of the linear model. It is generally accepted that a non-linear model is more flexible for espousing data, and thus outperforms the linear approach on the same dataset (Chen, 2011). (Note 4) To our knowledge, this type of research has not yet been conducted for forecasting university enrollment and funding.

The rest of this article is as follows. First, we go over the relevant literature on forecasting methods for both university enrollment and funding. Second, we detail the Quebec funding formula, its most recent changes and how it is adapted to a functional statistical model. We discuss at the same time how the dataset developed. Third, we present the results of three forecasting models in the main text, discuss the performance of the forecasts, and outline how the models yield forecasted subsidies that are quite different from the underlying enrollment. A brief conclusion follows. Finally, the remaining statistical models are summarized in Appendix B.

2. Literature

Time series models are a known paradigm for estimating a variety of topics (Box, Jenkins, Reinsel & Ljung, 2015). The literature mostly comprises univariate, autoregressive integrated moving average models (ARIMA) and the VAR models. Standard linear VAR techniques are explained in most econometrics' textbooks (e.g., Greene, 2017). The non-linear VAR technique is discussed thoroughly in Killian and Lütkepohl (2017).

ARIMA-based studies predict enrollment by looking at past enrollment values, as well as a few covariates (e.g., demographics). Those forecast models were developed and executed by Guérin (1972), Marshall and Oliver (1979), Shaw (1984), Kwak, Brown and Schiederjans (1986), Boes and Pflaumer (2006), Qin, Shanks and Philips (2019), Chen, Li and Hagerdorn (2019) and Loder (2023).

Linear VAR models aim at forecasting several variables simultaneously through linear relationships. Ewing, Beckert and Ewing (2010) use the paradigm to forecast enrollment, economic growth and inflation. It was also used by Wen-jian, Guang-Xing, Feng and Zheng-hui (2011) in order to analyse the supply and demand of the Chinese higher education system. We used VAR models to analyse the impact of COVID-19 on university finances for the province of Quebec, Canada (Bouchard St-Amant et al., 2020). As outlined in our introduction, our models tend to underestimate the public subsidies awarded to universities, in part because non-linear relationships are not captured by linear relationships.

2.1 History of Funding Changes

The Québec university funding formula has had several modifications in the last thirty years. However, most changes are related to shifting governmental priorities on relatively small appropriations compared to the overall funding (see Bouchard St-Amant et al., 2022a, for the history). In terms of large structural changes, the formula underwent two significant reforms during the 1994-2024 period. Prior to the year 2000, funding was historical (fixed) and incremental, meaning that university subsidies were planned based on the last year's subsidy, plus or minus adjustments based on specific projects (Ministère de l'Enseignement supérieur, 2024a). In the year 2000, following the pressure of a higher student demand, the formula switched from a historical to a predominantly enrollment-based formula (id.). Seventy-two funding weights were introduced, regrouping some programs together, to reflect the "average marginal cost" of a full-time equivalent (FTE) registration in a given program in the university network (Bouchard St-Amant, Brabant & Germain, 2020). (Note 5) Thus, the new funding formula allowed the funding to be a function of the cost differences between programs. Additional funding based on the number of FTE registered students, unweighted, is also given to cover the costs of auxiliary services, such as the funding of a library or student support services. Another funding component based on inputs was introduced, namely funding based on the number of buildings and the overall "superficy used for teaching," whose main metric was the number of square feet registered for teaching.

The formula remained largely unchanged until 2024, although the number of funding weights was reduced from 72 to 39 in 2018 (id., for the analysis). In 2024, the government introduced a graduation-based component, targeting sectors in shortage in the labor market, and reduced the overall proportion of the enrollment-based component by increasing fixed allocations (Ministère de l'Enseignement supérieur, 2024b). As of the writing of this article, this new graduation-based component has yet to be implemented.

2.2 The Quebec Funding formula

For the purpose of this article, four key elements of the formula are important: first, the way enrollment enters the formula is non-linear; second, there is both a weighted and an unweighted component to account for enrollment (both non-linear); third, the unit price converting enrollment in funding is growing over time; and finally, the almost fixed transfers for the non-enrollment-based funding.

We first look at the metric used to account for weighted enrollment. It is based on the highest value between a moving average over the last three complete academic years (t-2, t-3 and t-4) and the value of the last complete academic year (t-2). If one denotes the funding weights by $w_1 \ldots w_{39}$, the weighted FTE component is calculated by:

$$max\ \left(\sum_{i=1}^{39} w_i F_{it-2}\ , \frac{1}{3}\sum_{l=0}^{2}\sum_{i=1}^{39} w_i F_{it-2-l}\right) \tag{1}$$

The maximum is used to smooth funding if the most recent complete year suffered an important loss of enrollment. In such a case, the moving average (second term between brackets) is higher and smooths the loss over time. The funding is then found by multiplying this amount by a baseline price for weighted FTEs, converting the FTEs in dollars. Denote p_t the baseline price in year *t*, the funding component is then calculated by:

$$\mathrm{p_t max}\left(\sum_{i=1}^{39} \mathrm{w_i F_{it-2}}\ , \frac{1}{3}\sum_{l=0}^{2}\sum_{i=1}^{39} \mathrm{w_i F_{it-2-l}}\right) \tag{2}$$

Second and similarly, the unweighted component of the funding is determined by a similar smoothing component:

$$\widetilde{p_t} max(\sum_{i=1}^{39} F_{it-2}\ , \sum_{l=0}^{3}\sum_{i=1}^{39} F_{it-2-l}) \tag{3}$$

where the weights are omitted and the baseline price, noted $\widetilde{p_t}$, is different from the weighted enrollment base price (p_t). Third, the baseline prices are the main inputs through which the government adjusts the overall subsidy. When it has higher budgets, the baseline prices increase and when budget cuts must be made, the baseline prices diminish. Although the Department of Higher education (Ministère de l'Enseignement supérieur) strives for predictability, the base prices change with years and elected governments.

Finally, the almost fixed transfers ($\mathrm{T_{jt}}$) are the sum of actual fixed transfers and the funding component based on campus superficies. (Note 6) Accordingly, the complete funding formula takes the following form:

$$F_{jt} = T_{jt}\ +\ p_t max\left(\sum_{i=1}^{39} w_i F_{ijt-2}\ , \frac{1}{3}\sum_{l=0}^{2}\sum_{i=1}^{39} w_i F_{ijt-2-l}\right)\ +\ \widetilde{p_t} max\left(\sum_{i=1}^{39} F_{ijt-2}\ , \sum_{l=0}^{3}\sum_{i=1}^{39} F_{ijt-2-l}\right) \tag{4}$$

where F_{jt} and T_{jt} are respectively the funding and the transfers to the university j at time t (Bouchard St-Amant et al., 2022a). The formula allows us to directly calculate the funding if we have the values for each term in the equations. Contrary to linear forecasts, this approach has the advantage of directly addressing and estimating the non-linear component of the formula. The next section describes how we estimate each component of the formula and then estimate (by identity) the funding.

3. Methodology

We first describe the structural equations of the model and then characterize how we consistently estimate the coefficients and margins of error. We finish this section with a description of the dataset.

3.1 FTE Forecasts

Given the relatively good performance of our previous work, the overarching equation for forecasting FTEs has not changed, and is based on demographics, immigration, and past enrollment. As a reminder:

$$FTE_{jt} = \alpha_0 + \sum_{l=1}^{3} \rho_l FTE_{jt-l} + \alpha_1 u_t + \alpha_2 pop_t + \alpha_3 pop18_t + \alpha_4 immi_t + \alpha_5 GDP_t + \epsilon_{jt} \tag{5}$$

where the coefficients $\alpha_0 \dots \alpha_5$ and $\rho_1 \dots \rho_3$ are estimated statistically (see section 3.3), u_t is the unemployment rate, pop_t is the overall Québec population, $pop18_t$ is the Québec population from 18 to 25 years old, $immi_t$ is the immigration influx in the province, and GDP_t is the gross domestic product.

3.2 Public Subsidy Forecasts

The starting point of our forecasting model is the equation (4) determining the funding for one university, $j = 1, \dots, 18$:

$$F_{jt} = T_{jt} + p_t \max\left(\sum_{i=1}^{39} w_i F_{ijt-2}, \frac{1}{3}\sum_{l=0}^{2}\sum_{i=1}^{39} w_i F_{ijt-2-l}\right) + \tilde{p}_t \max\left(\sum_{i=1}^{39} F_{ijt-2}, \sum_{l=0}^{3}\sum_{i=1}^{39} F_{ijt-2-l}\right) + \epsilon_{jt} \tag{6}$$

where F_{jt} is the funding awarded to university *j* at time *t*, and T_{jt} encompasses almost fixed transfers and ϵ_{jt} is the residual, idiosyncratic funding.

The novel approach of this paper is to forecast equation (6) using five equations, one for each of the following terms: $\tilde{p}_t$, p_t, FTE_{jt}, FTE_{jt}^{w}, and T_{jt}. We then obtain the funding by assembling the terms according to the equation. The baseline prices are formula specific and identical in all universities. We forecast them with a first-order autoregressive model that includes a structural break in 2018 and 2022:

$$\tilde{p}_t = \delta_0 + \delta_1 \tilde{p}_{t-1} + \delta_2 (I_{2018\,t} \cdot \tilde{p}_{t-1}) + \tilde{e}_t \tag{7}$$

$$p_t = \phi_0 + \phi_1 p_{t-1} + \phi_2 (I_{2022\,t} \cdot p_{t-1}) + e_t \tag{8}$$

where $\delta_0 \dots \delta_2, \phi_0 \dots \phi_2$ are estimated statistically and the binary variables $I_{2018,t}$, $I_{2022,t}$ define the structural breaks in, respectively, 2018 and 2022. Thus, the coefficients δ_2 and ϕ_2 capture the permanent change in the slope after 2018 and 2022 respectively.

The forecast on weighted FTEs (FTE_{jt}^{w}) is given by:

$$FTE_{jt}^{w} = \kappa_0 + \kappa_1 FTE_{jt} + \kappa_2 FTE_{jt-1} + \kappa_3 FTE_{jt-1}^{w} + e_{4t} \tag{9}$$

We consider only one lag on weight FTEs, which has proven to be enough empirically. Last but not least, fixed transfers are estimated with the following, overarching model:

$$T_{j,t} = \lambda_0 + \lambda_1 t + \lambda_2 (t \cdot I_{2018,t}) + \lambda_3 I_{2018,t} + e_{5,t} \tag{10}$$

where $\lambda_0 \dots \lambda_3$ are estimated coefficients, and t is the year. Thus, λ_2 acts as a slope change after 2018 and λ_3 acts as an intercept change after 2018.

3.3 Estimation Technique

Each equation is estimated first through ordinary least squares. This yields consistent point estimates with incorrect margins of errors (Greene, 2017). The correct margins of error are obtained by bootstrapping the residuals (Davidson & MacKinnon, 2006; Hamilton, 1994). Two aspects are important in this context. First, the dependency of the variables at each period must be considered. This implies that the residuals are chosen by selecting randomly a period that applies to each equation. Second, the dependency between periods must be preserved. The bootstrapping technique used meets those two criteria.

Each university specific equation presented above is adapted to each university. Specifically, statistically insignificant variables are removed, and we further adapt the covariates (demographics, immigration, etc.) by changing the time index (*t, t-1, t-2*) so as to maximize the forecasting power. (Note 7) Each equation thus ends up being university specific.

3.4 Data

The core dataset is the same as in Bouchard St-Amant et al. (2020). In particular, the funding and enrollment data, the transfers and the economic indicators are constructed from the same data sources. The funding, enrollment and transfers were extracted from the aggregated public financial statements (Ministère de l'Enseignement supérieur, 2000 to 2023) and the announced appropriations for the current year (Ministère de l'Enseignement supérieur, 2024a). The economic indicators were extracted from national and provincial agency, and forecasts from the main banks in Quebec. (Note 8)

The dataset is supplemented with the baseline prices, both for the weighted and non-weighted FTEs. They are extracted from the aggregated public financial statements (Ministère de l'Enseignement supérieur, 2000 to 2023) and the announced appropriations for the current year (Ministère de l'Enseignement supérieur, 2024a). The prices were extracted manually and then verified. Figure 2 shows the prices, with structural breaks in 2018 and 2022 in each price series. This coincides with the 2018 reform (Bouchard St-Amant, Brabant & Germain, 2020) and the beginning of the second mandate of the current government (Directeur général des élections, 2024).

4. Results

We begin by presenting the estimation of the FTE baseline prices ($\widetilde{p_t},\ p_t$), then present the results for three selected universities. The estimations of the remaining models are found in Appendix B. We conclude with a discussion of the results.

4.1 Baseline Prices

Each year, the government determines the baseline prices by the subsidy available for each normative foundation and then dividing by the proper number of FTEs. Weighted FTEs are used as a proxy for the cost of various programs. Unweighted FTEs are used as a proxy for auxiliary services related to programs (e.g., library). The share of the FTEs that each university has thus determines the share of the total appropriations available. The subsidies available are the result of the Ministry of Higher Education demands in the global provincial budget process (Cliche, 2017).

The forecasts of the baseline prices ($\widetilde{p_t},\ p_t$) are shown in Figure 2. The estimated coefficients of equations (7) and (8) are shown in Table 3. The table shows the statistical significance of the binary variables $I_{2018\,t}$ and $I_{2022\,t}$. This shows that each has a change in trends. These years have a meaning with respect to the funding formula. Year 2018 corresponds to the last important policy change to the Québec formula, where the number of funding weights was reduced. Year 2022 is the first budget year of the second mandate of the government.

Incorporating the changes in the baseline price trends is the first improvement in the methodology. In a linear setup, they can only be modelled as constant in time. If the values increase with time, the difference between the linear estimation and the realized value weakens the forecasting power of the model.

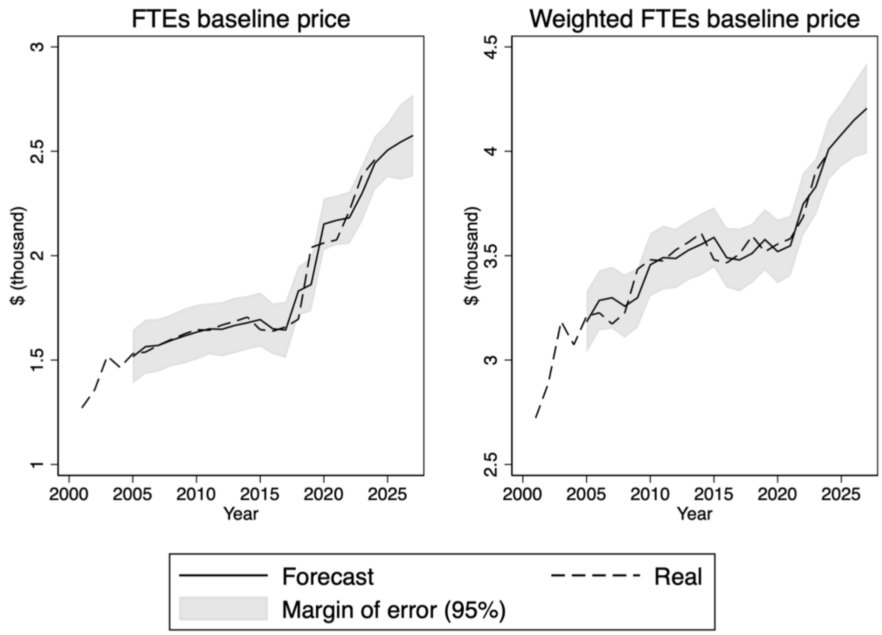

Figure 2. Graphical Forecast of Baseline Prices ($\widetilde{p_t}$ and p_t)

Sources: Author’s calculations and Ministère de l’Enseignement supérieur (2000 to 2024a).

Table 3. Estimation of the Baseline Prices ($\widetilde{p_t}$ and p_t)

	$\widetilde{p_t}$	p_t
Lagged variable	0.7386***	0.7564***
	(0.1021)	(0.0764)
$I_{2018\ t}$	0.1034***	
	(0.0288)	
$I_{2022\ t}$		0.0503***
		(0.0160)
Constant	0.4340**	0.8580***
	(0.1601)	(0.2564)
R^2	0.95	0.90
Adj. R^2	0.9452	0.8913
N	23	23

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieur (2000 to 2024a).

4.2 Forecast Results

We forecast simultaneously equations (5) to (10) for each university. In the main text, we present the results for three universities: Concordia University, McGill University and Université du Québec à Chicoutimi. These three universities were chosen to show explicitly the disconnect between enrollment patterns and public subsidies. The other universities' forecasts are reported in Appendix B.

Concordia University's forecast model is shown in Table 4, while the forecasts are illustrated in Figure 3. Two key ideas should be seen from the model. First, enrollment patterns are stagnant or in slow decline since 2010. This is so for both weighted enrollment and unweighted enrollment. (Note 9) Second, funding has steadily increased since 2018. Concordia's increase in funding stems from both the increase in the baseline prices, increasing the funding per FTE, and from the increase in fixed transfers. The two bottom coefficients of Table 4 convey the sharp change in trend around 2018. Prior to the funding reform, the university had fixed transfers in decline (a loss of 3,266 thousand dollars per year), while it has started to increase after the reform (a gain of 9,822 thousand dollars per year).

McGill University's forecast model is shown in Table 5, and the forecast is illustrated in Figure 4. Overall, the forecasts show patterns similar to Concordia, although the changes in enrollment are steeper and the pattern for fixed transfers is perhaps more chaotic. The net effect is still an increase in public subsidy, although the post-2018 increase is less steep than Concordia.

Perhaps the most striking pattern of disconnect between enrollment and funding is shown with Université du Québec à Chicoutimi (Table 6 and Figure 5). For this university, there is a recent and sharp decline in enrollment. This means that, compared to McGill or Concordia, there is a third aspect of the formula that accounts for the preservation of funding. Recall that equation (6) takes the highest value of enrollment in t-2 and the moving average of enrollment in t-2, t-3 and t-4. Because enrollment declines, the moving average always yields a higher value than the enrollment in t-2. As such, the university's funding is smoothed by losing only one third (33%) of its current enrollment rather than a full account. Combined with the increase in the baseline prices and the increase in fixed transfers, the net effect is also an increase in funding over time, despite the sharp decrease in enrollment.

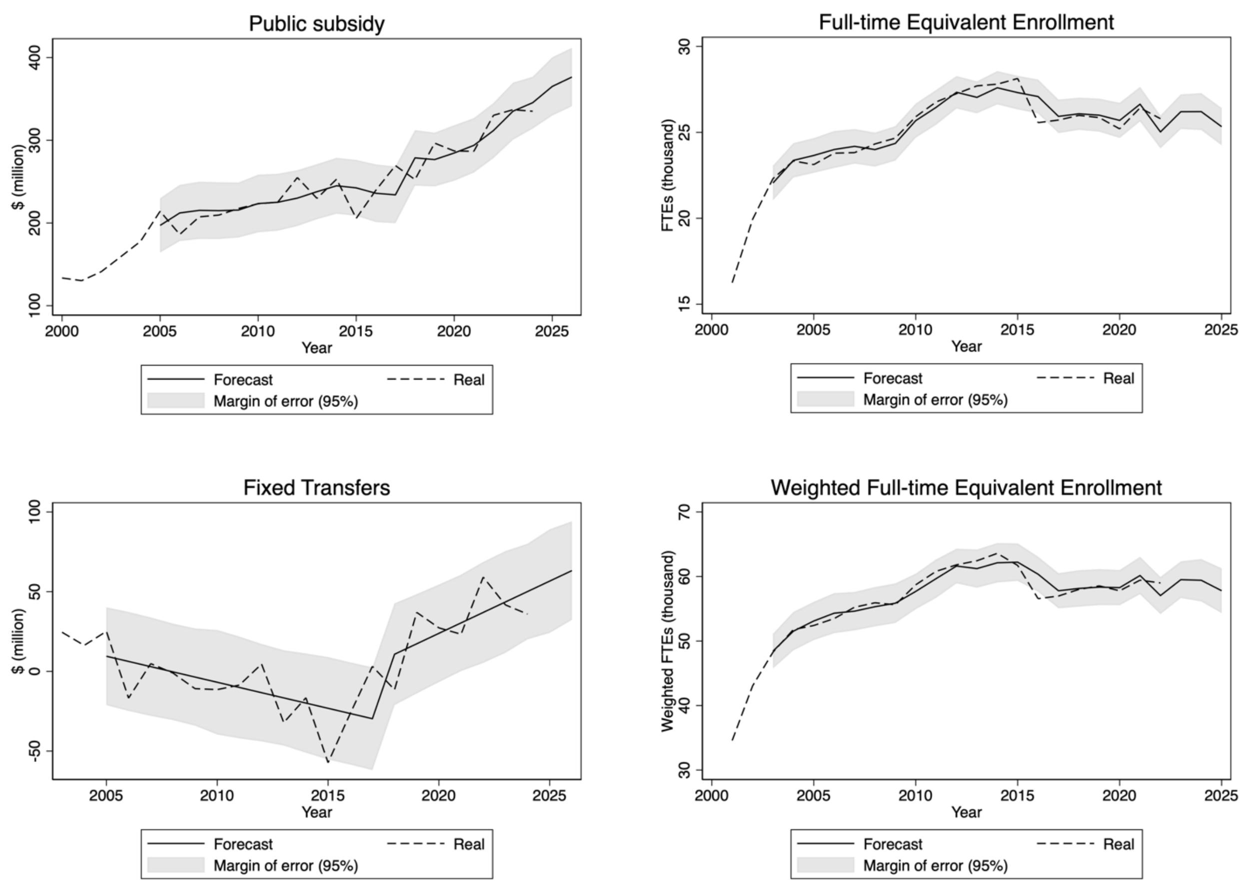

Figure 3. Concordia University

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table 4. Estimation of FTEs, Weighted FTEs and Fixed Transfers for Concordia

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.3841***	-1.0070**	
FTE_{jt-2}		1.7753***	
u_{t-3}	689.5530***		
pop_{t-3}	0.0090		
pop_{t-4}	-0.0074		
$immi_{t-4}$	0.1258**		
FTE^{w}_{jt-3}		0.6027***	
$I_{2018,t}$			-1.9778e+07**
t			-3266.0012***
$t \cdot I_{2018,t}$			9822.6083**
Constant	-8785.6320	3409.9201	6 557 837.4768***
R^2	0.93	0.98	0.67
Adj. R^2	0.9124	0.9732	0.6115
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

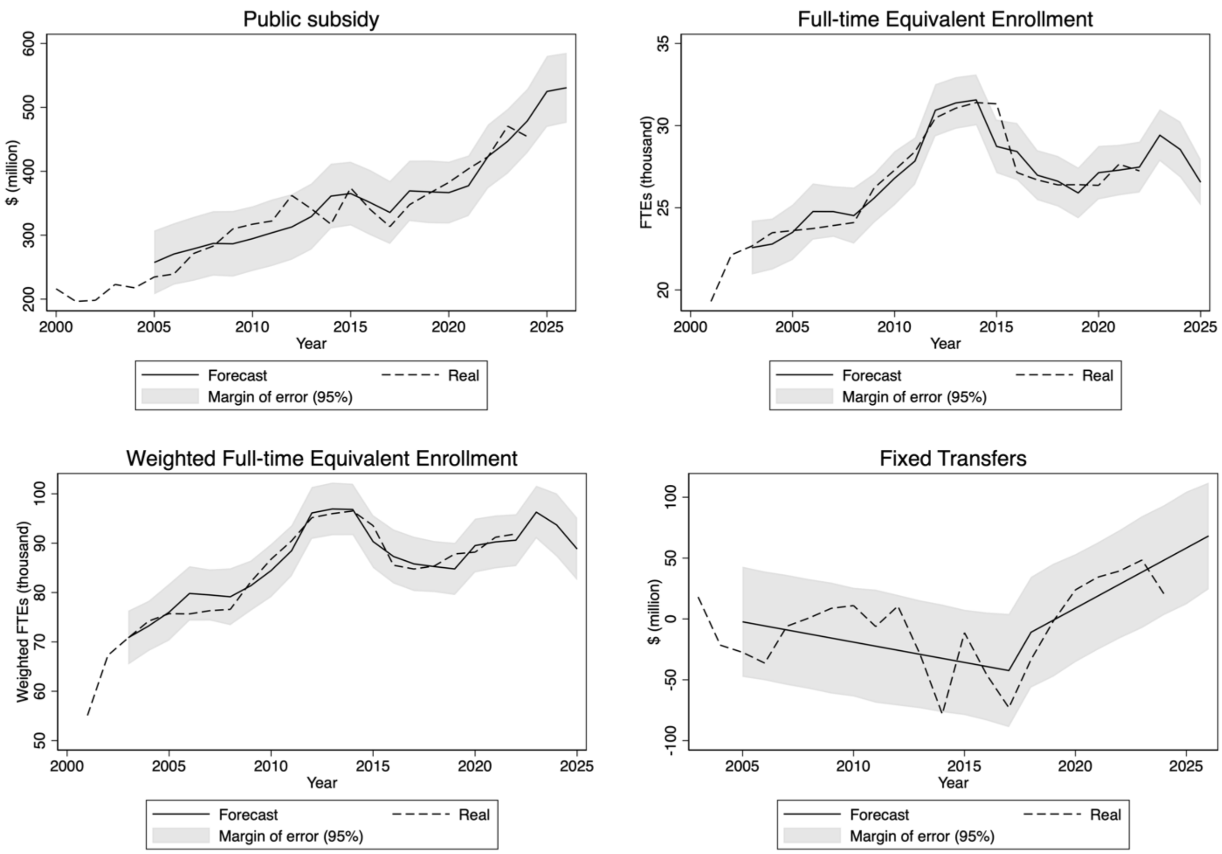

Figure 4. McGill University

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a)

Table 5. Estimation of FTEs, Weighted FTEs and Fixed Transfers for McGill University

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
pop_{t-5}	0.0681***		
pop_{t-6}	-0.0519***		
$immi_{t-2}$	0.1490***		
$immi_{t-4}$	0.3118***		
GDP_{t-6}	-0.0953***		
FTE_{jt-2}		2.2176***	
FTE_{jt-3}		-1.9983***	
FTE^{w}_{jt-3}		0.8314***	
$I_{2018,t}$			-2.6657e+07**
t			-3337.3614**
$t \cdot I_{2018,t}$			13226.7164**
Constant	-95 553.8238***	9099.7270***	6 689 048.1528**
R²	0.93	0.98	0.53
Adj. R²	0.9084	0.9773	0.4533
N	22	21	22

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a). Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

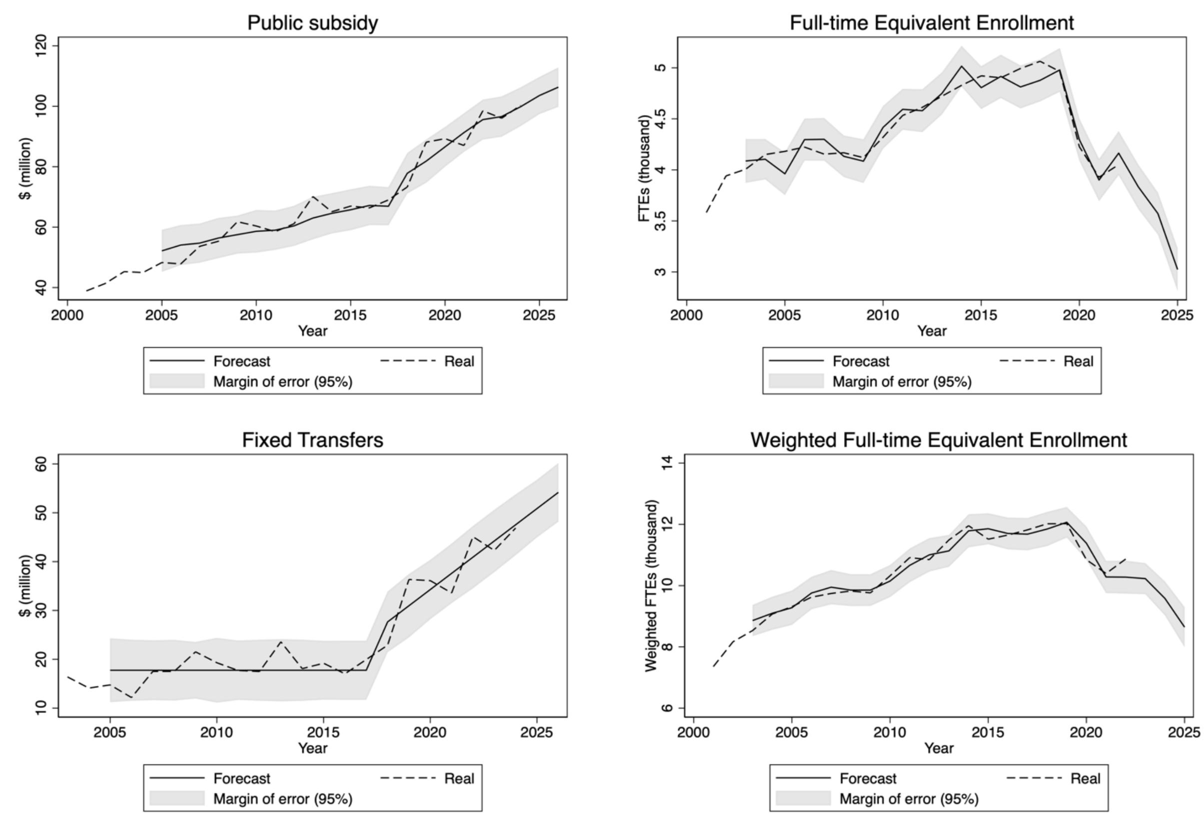

Figure 5. Université du Québec à Chicoutimi

Table 6. Estimation of FTEs, Weighted FTEs and Fixed Transfers for UQAC

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
u_{t-3}	288.0586*		
u_{t-4}	5.9120		
pop_{t-2}	0.0140***		
pop_{t-3}	-0.0238***		
pop_{t-4}	0.0129***		
GDP_{t-2}	0.0019		
GDP_{t-3}	-0.0137		
$immi_{t-2}$	-0.0531***		
$immi_{t-4}$	0.0718***		
FTE_{jt-2}		1.0018***	
FTE^{w}_{jt-3}		0.6009***	
$I_{2018,t}$			-6 680 846.2254***
$t \cdot I_{2018,t}$			3315.5307***
Constant	-18 985.1693**	-142.3354	17 758.1289***
R^2	0.94	0.94	0.91
Adj. R^2	0.8897	0.9375	0.9047
N	22	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

5. Discussion

The universities we have chosen to discuss in the main text are not isolated cases of decline in enrollment, but rather examples of the general trend. (Note 10) Figure 6 shows the pattern for the whole province of Québec and, if need be, the reader can peruse the appendix to look at the trend. The stagnation in enrollment can easily be seen at the same time as an increase in the public subsidy. This goes against the notion that enrollment is the main driver of accrued subsidies despite the fact that the formula is enrollment based.

The figures underline the impact of three shifts since the 2018 formula reform. First, the increase of the baseline prices, second the increase in fixed transfer, and third the impact of moving average mechanisms to slow the funding decline. These three effects are overlooked if one simply looks at enrollment trends.

These three shifts are of course specific to the jurisdiction studied, but perhaps a more applicable takeaway is that despite a strong underlying narrative for building a funding formula, it may be best to look at the finer details to see if the narrative permeates the allocation rules. If the formula is filled with exceptions, safeguards and reweightings, there may be a disconnect between the narrative and the actual allocation.

A chief example, not related to forecasts, is the funding formula for universities in the province of Ontario. The new formula is output based and tied to metrics related to employment such as the market placement of graduates, their wage, or the unemployment rate of the sector (Bouchard St-Amant et al., 2022b). By looking at those metrics, one may think that the policy provides strong incentives to align university activities with market outcomes. However, a finer read of the formula shows that universities are allowed to choose some metrics within the chosen set established by the government. Accordingly, universities can choose the metrics that already maximize their funding, producing absolutely no incentive for change. One interpretation is that the formula is disconnected from its intent. Another is that the department designed the formula to protect universities from a political intent that was deemed too oriented toward the market. In other words, the disconnect may not be intentional, but it could be.

Back to Québec, the most recent (2024) but yet to be implemented funding reform further reduces the dependency of the funding to enrollment by decreasing the percentage of total appropriations that are tied to enrollment and by increasing fixed funds. Combined with the 2018 reform, it suggests overall a slow but planned change over time.

Although speculative, we can think of two reasons why the Department of Higher Education may reduce the dependency on enrollment. First, it protects the university funding from medium-term enrollment fluctuations, providing financial stability and, thus, a greater ability to plan initiatives. This was certainly argued in the pre-reform report that was commissioned to study funding formulas in various jurisdictions (id.). Second, the motives may be even more protective. The department may wish to change the funding formula in order to keep the already established subsidies during Treasury Board evaluations. If the formula had kept the same structure as the pre-2018 version, the overall appropriations dedicated to universities would have declined. By changing the narrative of the formula, the department is thus able to maintain the funding.

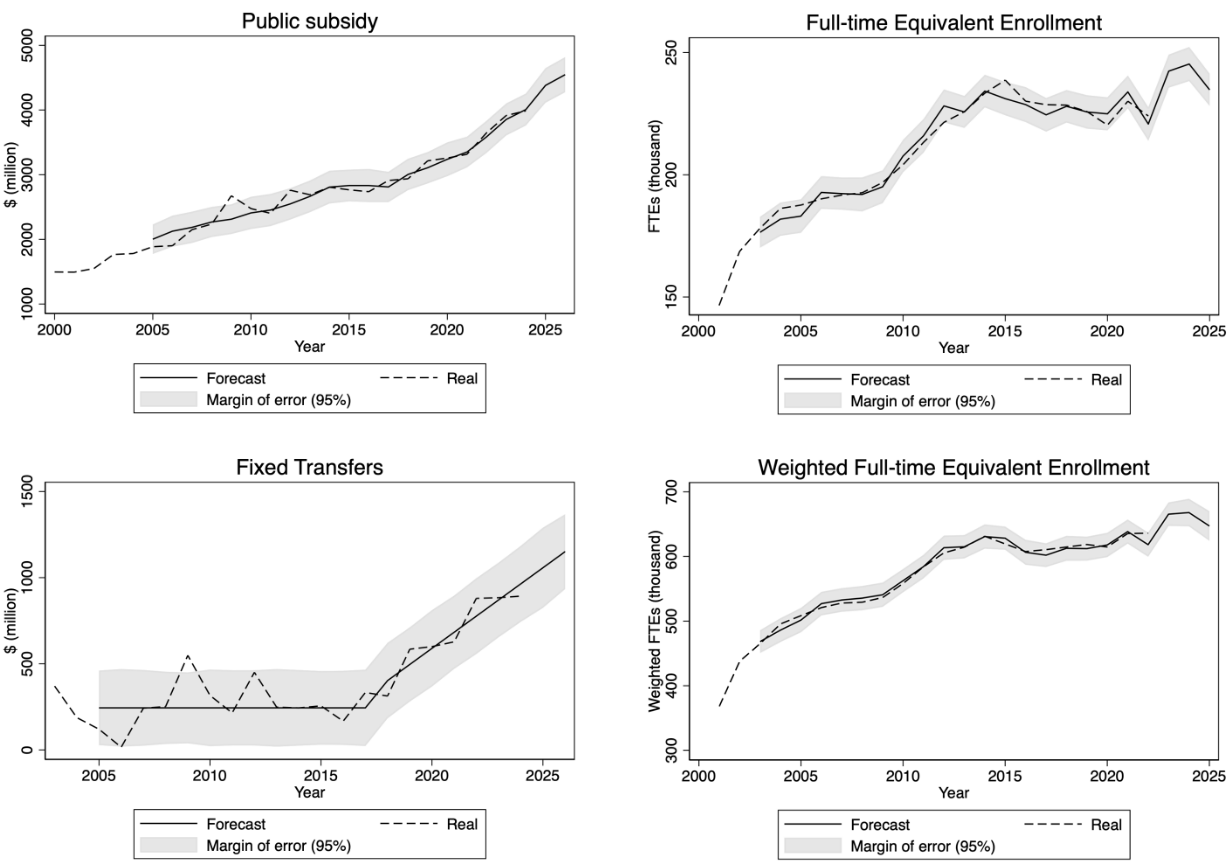

Figure 6. Graphical Forecasts for the Whole Province

Note: The fixed transfers for 2009 are considered an outlier when estimating the model.

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

6. Conclusion

This article contributes to the literature by providing three novel aspects to the study of funding formulas. It incorporates non-linear vector auto-regressive models for the forecasting of public subsidies, and it provides models for all of the eighteen universities in Québec, Canada. These can be used for the aforementioned province, but the article also provides a ready-made recipe for forecasts in other jurisdictions.

More importantly, the article further explains why non-linearities are important and how they should be incorporated in forecasts. In the case at hand, the increases in funding per student, the decline in the percentage of appropriations tied to enrollment and smoothing mechanisms are three factors that cannot be accounted for by a simple linear relationship tying enrollment to subsidies. From a normative standpoint, these three notions are so important that they disconnect the relationship between enrollment and subsidies, despite the fact that the formula is enrollment based. This shows that one needs to look beyond the overarching narrative and take a serious look at the actual funding rule.

We can only surmise that this finding is not an isolated case and can probably be found in other jurisdictions. It is, in our views, a promising avenue for future research.

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Notes

Note 1. For example, Figure 6 shows the funding for the whole province. We observe that the funding tied to enrolments represents about three quarters of total subsidies.

Note 2. Linear VARs models to forecast simultaneously the funding and enrollment were used in the previous work (Bouchard St-Amant et al., 2020). In particular, the funding was a function of lagged values and enrollment. The general equation for funding in the previous article thus takes the following form: $F_{jt} = \beta_0 + \beta_1 F_{jt-1} + \beta_2 F_{jt-2} + \sum_{i=0}^{2} \delta_i FTE_{jt-2-i} + e_{jt}$, with F_{jt} and FTE_{jt} the funding and enrollment at time t for university j. The term e_{jt} is the estimation error. As for the enrollment, the forecasted values were a function of lagged values and economic indicators, such as unemployment, total population size and yearly number of immigrants in Quebec.

Note 3. The complete name of all Quebec universities can be found in Appendix A. The complete forecasts of the linear VAR models can be found in Appendix C.

Note 4. In this specific instance, non-linear models allow the forecaster to model almost perfectly funding formulas. As such, it does not generate statistical noise induced by an improper model selection.

Note 5. Although not convincingly documented, there is some belief that these average marginal costs lead some universities to develop campuses and programs where the "profit margins" were the highest. There is some partial evidence for this behaviour documented in Crespo, Beaupré-Lavallée and Dubé (2011). Also consistent with this belief, the Department of Higher Education later regulated the creation of new programs, limiting university autonomy, in part to control costs.

Note 6. Both are considered “fixed transfers” in the short run, leading one to think of the component T_{jt} as with little variations.

Note 7. The equation for funding is the same for each university, as we estimate the actual funding formula. Each university then differs in the equations used to forecast the terms of the formula. Moreover, for the funding, because we estimate the actual formula, we are not confronted with the problem of overfitting the data.

Note 8. A complete description of the sources mentioned above is available in the previous article (Bouchard St-Amant et al., 2020).

Note 9. Although this is not the case here, it is possible to observe increases in weighted enrollment when unweighted enrollment declines or stagnates. This happens when there is an enrollment shift from programs with a low weight toward programs with a higher weight. The converse can also happen.

Note 10. A few exceptions exist where enrollment increases, such as with HEC Montréal and Institut national de recherche scientifique.

Appendix A

Acronyms Used for the Universities

Acronyms	University names
QC	Aggregate trends for the Québec province
UQ	Aggregate trends for the ten universities in Université du Québec
Bishop’s	Bishop’s University
Concordia	Concordia
ENAP	École nationale d’administration publique
ETS	École de technologie supérieure
HEC	HEC Montréal
INRS	Institut national de la recherche scientifique
McGill	McGill University
Poly	École Polytechnique de Montréal
UL	Université Laval
UdS	Université de Sherbrooke
UdM	Université de Montréal
UQAC	Université du Québec à Chicoutimi
UQAM	Université du Québec à Montréal
UQAR	Université du Québec à Rimouski
UQAT	Université du Québec en Abitibi-Témiscamingue
UQO	Université du Québec en Outaouais
UQTR	Université du Québec à Trois-Rivières
TELUQ	Université TÉLUQ

Appendix B

Results for Remaining Universities

The forecast models for Concordia University, McGill University and Université du Québec à Chicoutimi can be found in the main text.

Whole Province

This forecast model is for the whole university network. It may prove useful for the Department of Higher Education. The graphical forecast is in the main text (Figure 6).

Table B1. Estimated Model for the Whole Province

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
u_{t-3}	6739.7606***		
pop_{t-4}	0.0453***		
$immi_{t-4}$	2.0126***		
FTE_{jt-2}		1.7540***	
FTE_{jt-3}		-1.4579***	
FTE^{w}_{jt-3}		0.8195***	
$I_{2018,t}$			-1.8863e+08***
$t \cdot I_{2018,t}$			93 551.8393***
Constant	-292 560.6430***	45 681.7896**	244 230.6696***
R^2	0.97	0.99	0.86
Adj. R^2	0.9703	0.9839	0.8459
N	22	21	21

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Université du Québec

Université du Québec comprises ten universities, namely, all universities whose acronym begins with UQ, ETS, ENAP and INRS. It is a public university system, in principle similar to the University of California system or the City University of New York system.

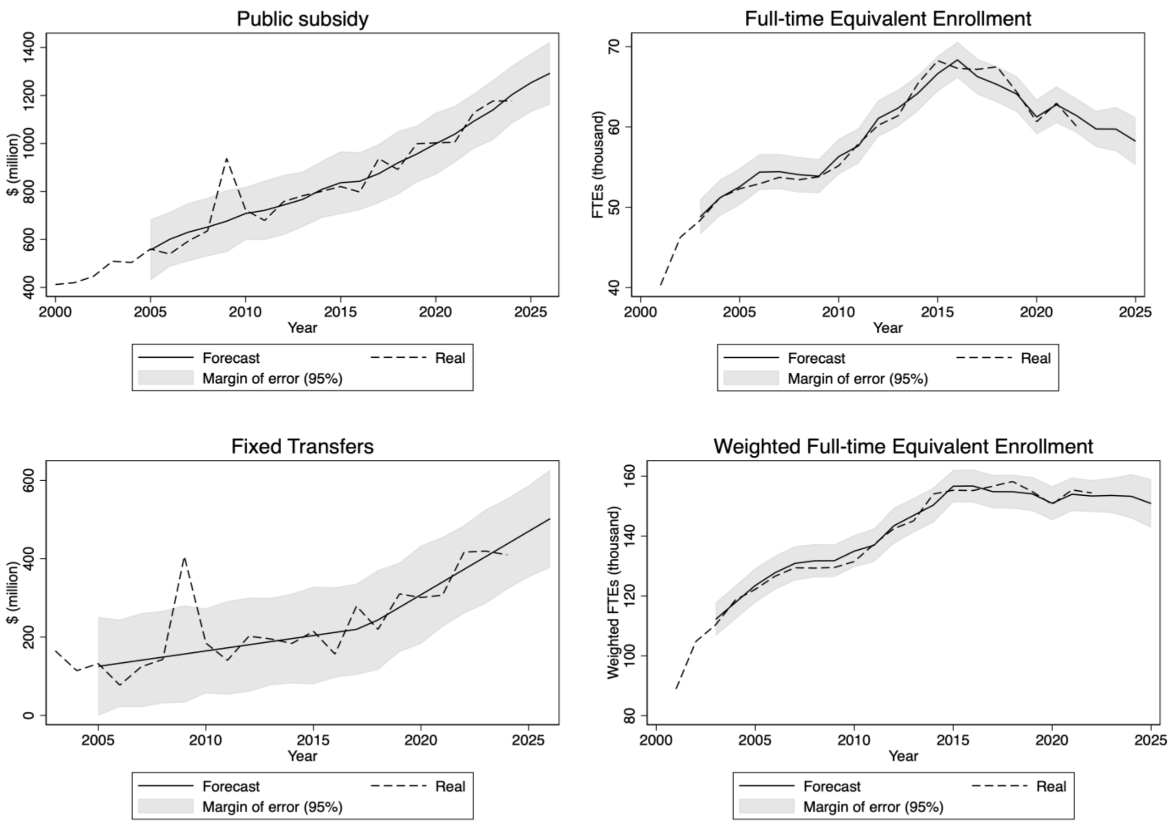

Figure B1. Graphical Forecasts for Université du Québec

Note: Year 2009 is considered an outlier and is removed from the forecast.

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B2. Estimated Model for Université du Québec

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.6801***	-1.2149***	
FTE_{jt-2}		1.4258***	
u_{t-3}	1583.2552***		
pop_{t-3}	-0.0200		
pop_{t-4}	0.0233		
$immi_{t-4}$	0.2740**		
FTE^{w}_{jt-3}		0.8581***	
$I_{2018,t}$			-4.9327e+07***
t			7873.6016***
$t \cdot I_{2018,t}$			24 451.2600***
Constant	-30096.6165**	8912.1590**	-1.5661e+07***
R^2	0.97	0.99	0.90
Adj. R^2	0.9603	0.9896	0.8822
N	21	21	21

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Bishop's University

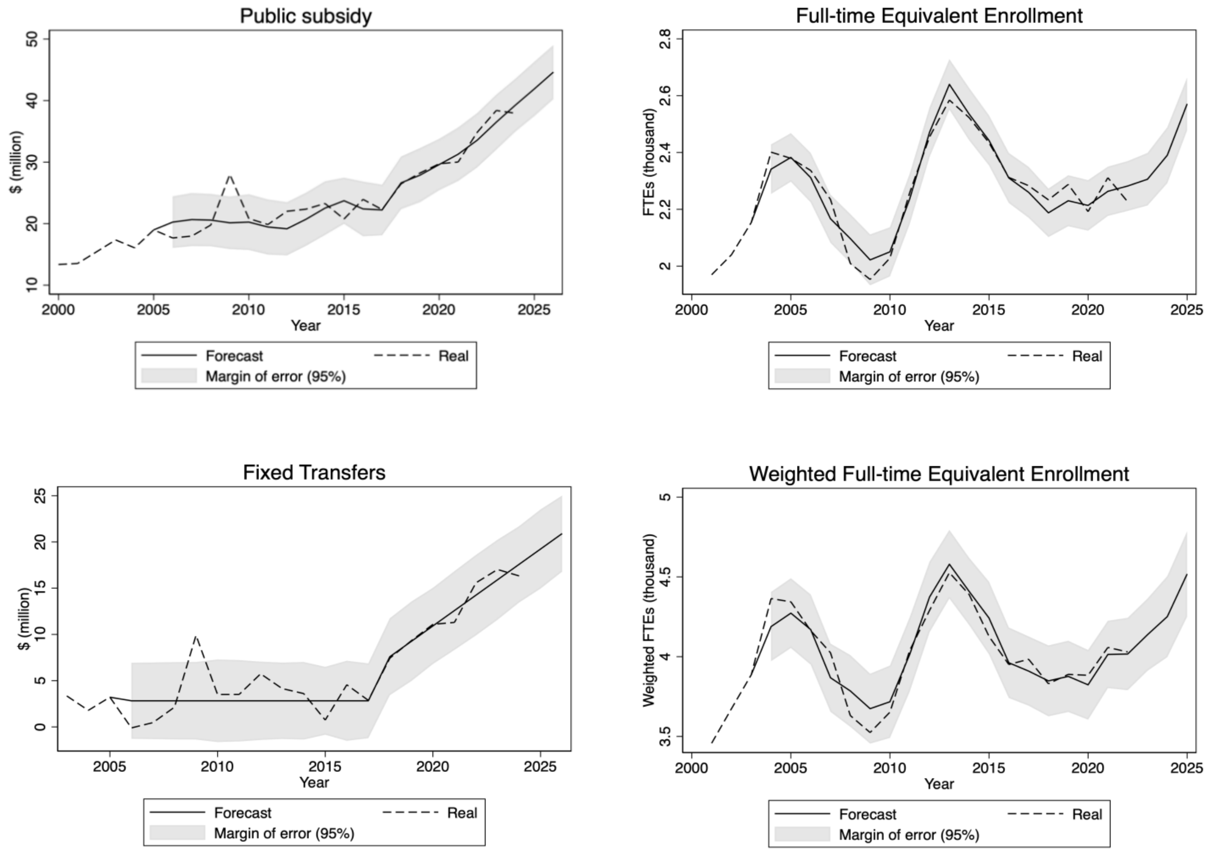

Figure B2. Graphical Forecasts for Bishops University

Note: The fixed transfers for 2009 are considered an outlier when estimating the model.

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B3. Estimated Model for Bishop's University

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.4268***	-1.1865***	
FTE_{jt-5}	-0.8261***		
FTE_{jt-2}		1.6256***	
pop_{t-3}	-0.0022***		
pop_{t-5}	0.0023***		
$immi_{t-5}$	0.0159***		
FTE^{w}_{jt-3}		0.6513***	
$I_{2018,t}$			-3 352 693.2691***
$t \cdot I_{2018,t}$			1663.7570***
Constant	1913.2603***	406.5276*	2825.3075***
R^2	0.92	0.95	0.93
Adj. R^2	0.8947	0.9419	0.9181
N	19	21	21

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

École Nationale d'administration Publique

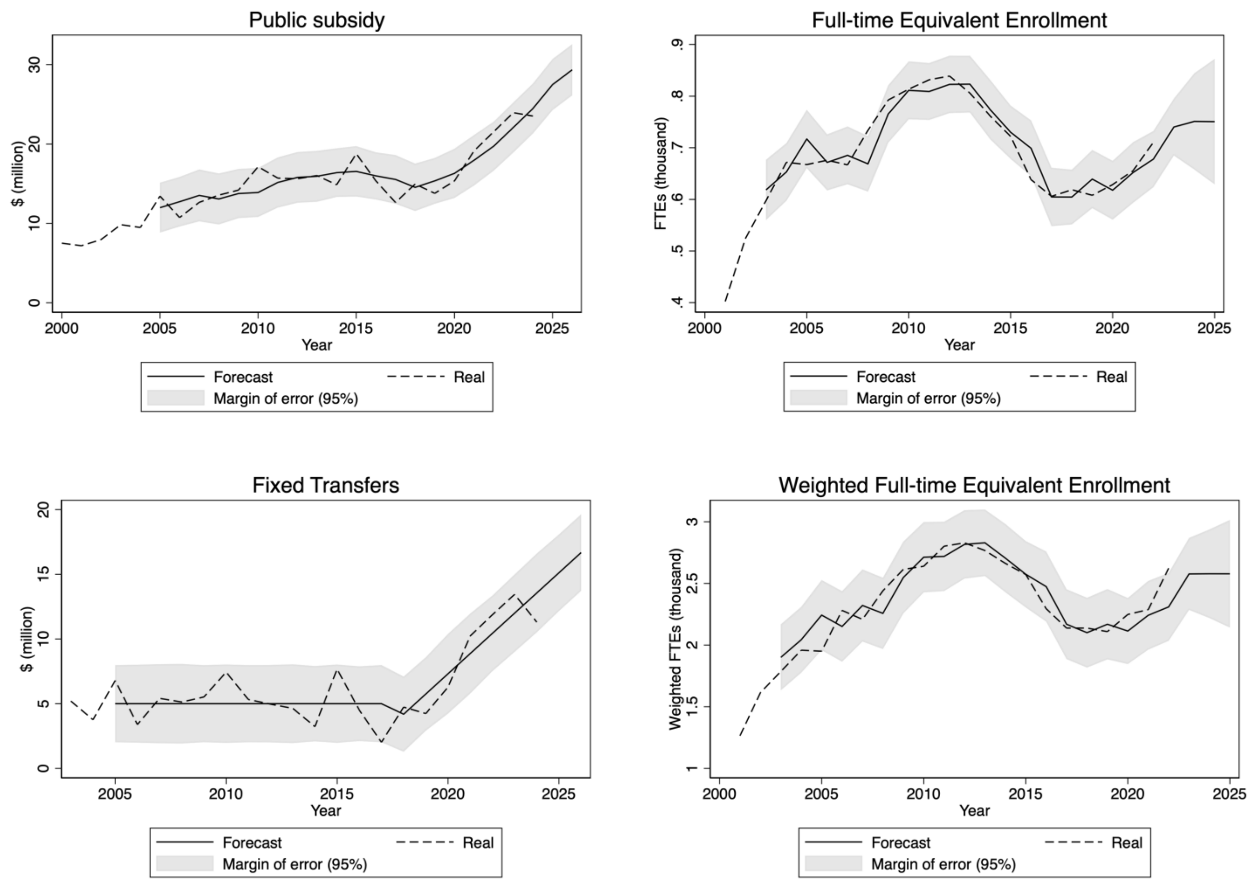

Figure B3. Graphical Forecasts for École nationale d'administration publique

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B4. Estimated model for École nationale d'administration publique

	FTE_{it-2}	FTE^{w}_{it-2}	$T_{i,t}$
FTE_{it-3}	1.3795***		
FTE_{it-4}	-0.5314***		
FTE_{it-2}		1.9618***	
FTE^{w}_{it-3}		0.4340***	
$I_{2018,t}$			-3151165.1664***
$t \cdot I_{2018,t}$			1561.1271***
Constant	107.8113*	-13.2552	4999.0084***
R^2	0.87	0.93	0.74
Adj. R^2	0.8559	0.9169	0.7167
N	20	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

École de Technologie Supérieure

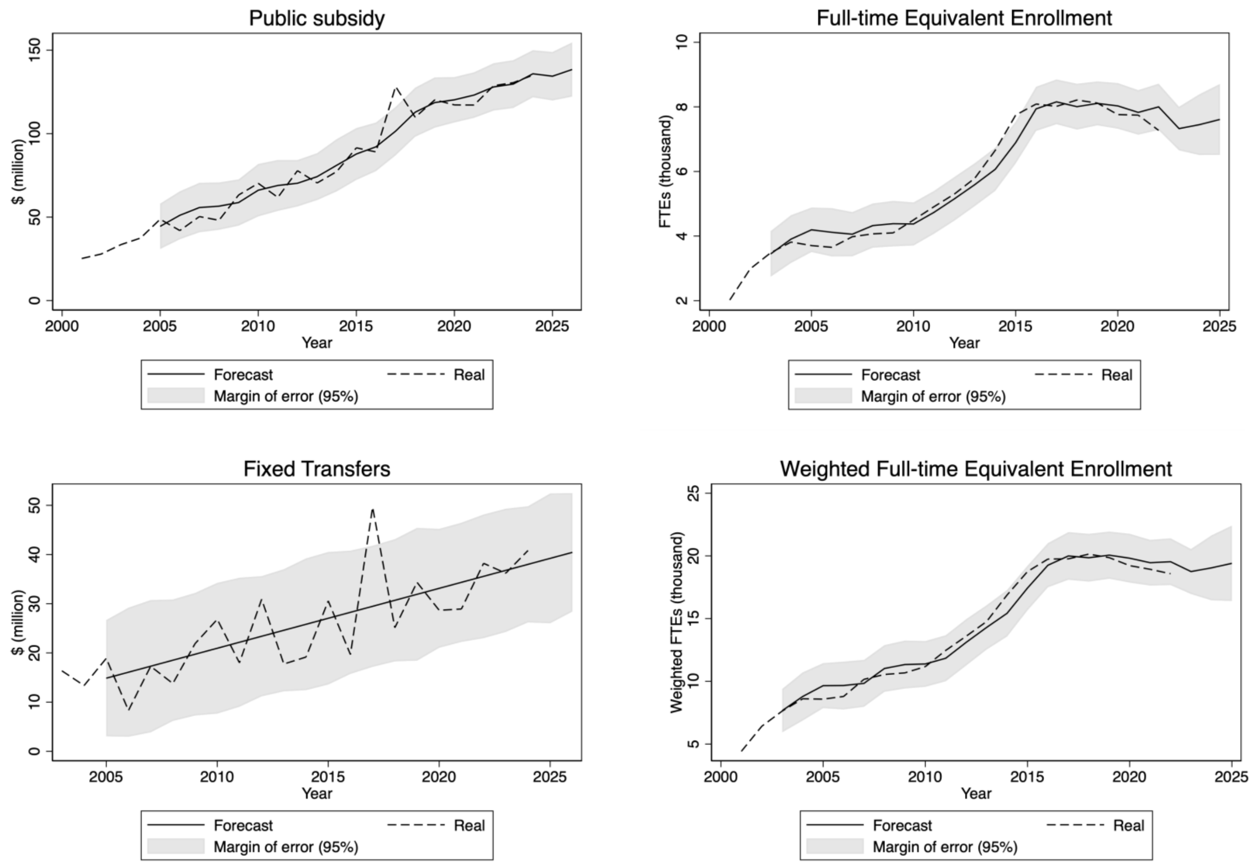

Figure B4. Graphical Forecasts for École de technologie supérieure

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B5. Estimated model for École de technologie supérieure

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.9035***	-1.6475***	
FTE_{jt-2}		1.8490***	
pop_{t-3}	-0.0037		
pop_{t-4}	0.0038		
FTE^{w}_{jt-3}		0.9028***	
t			1217.8177***
Constant	-214.1783	412.7091*	-2426862.1468***
R^2	0.96	1.00	0.59
Adj. R^2	0.9578	0.9969	0.5695
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

HEC Montréal

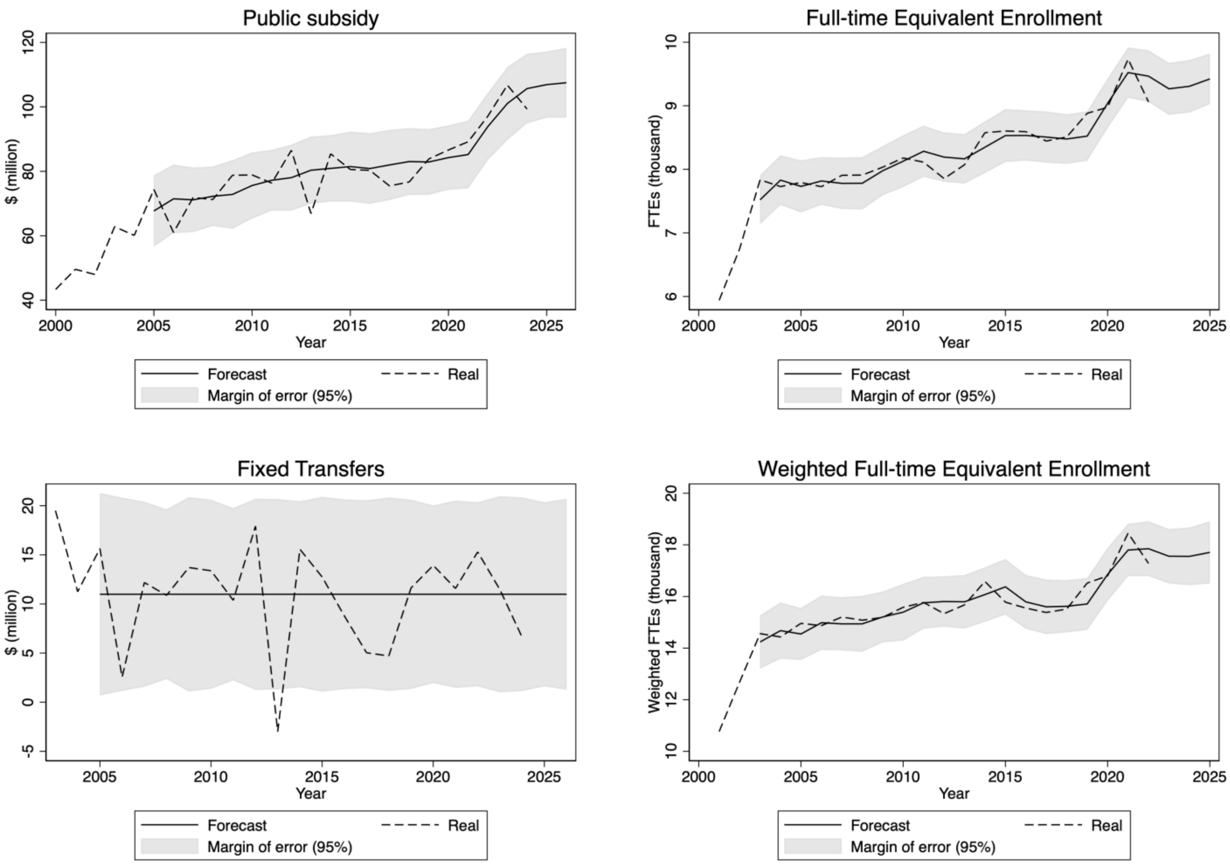

Figure B5. Graphical Forecasts for HEC Montréal

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Table B6. Estimated model for HEC Montréal

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.3148**	-1.3041***	
FTE_{jt-2}		1.8122***	
u_{t-2}	206.5640**		
GDP_{t-2}	0.0174**		
GDP_{t-3}	-0.0116*		
FTE^{w}_{jt-3}		0.6899***	
Constant	1873.6475	658.8161	10987.6619***
R^2	0.89	0.96	0.00
Adj. R^2	0.8637	0.9496	0.0000
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Institut National de Recherche Scientifique

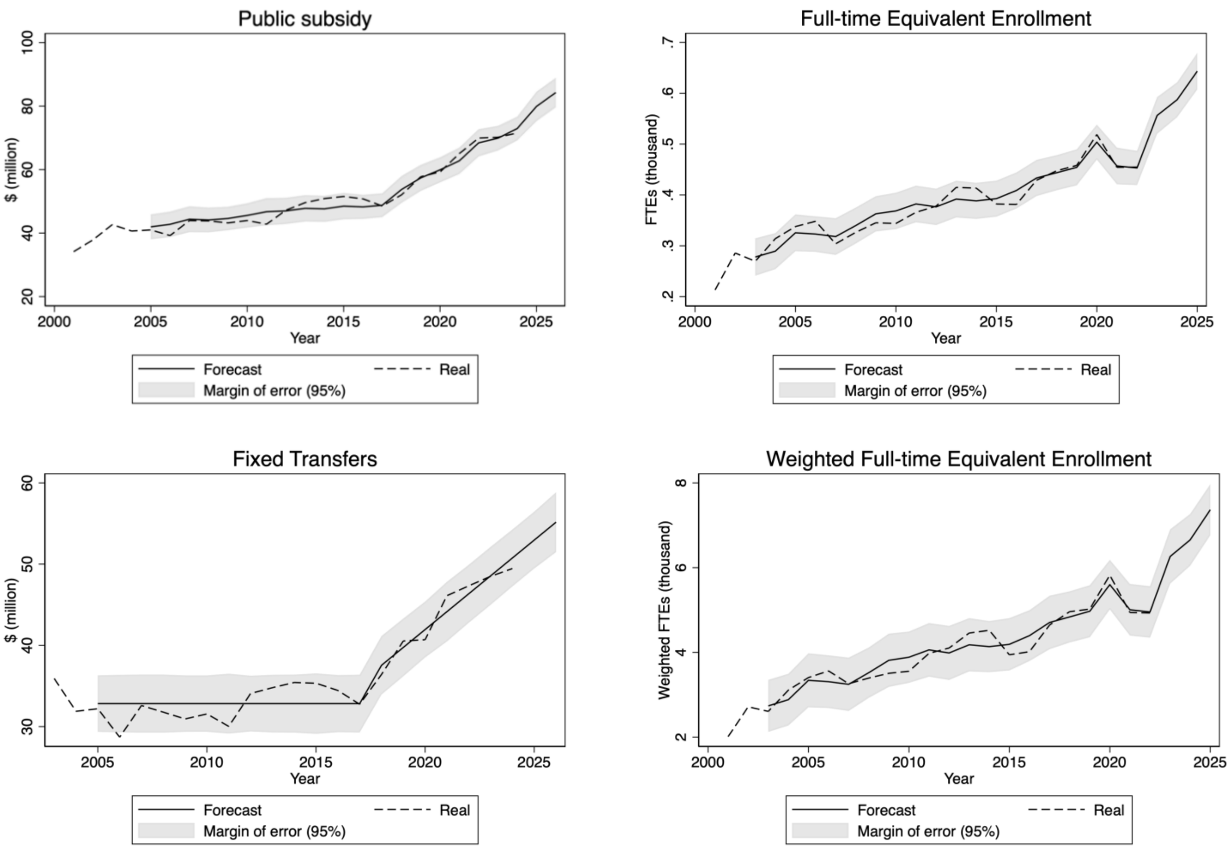

Figure B6. Graphical Forecasts for Institut national de recherche scientifique

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B7. Estimated model for INRS

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
u_{t-4}	33.3372**		
pop_{t-3}	0.0007**		
pop_{t-4}	-0.0009**		
GDP_{t-2}	-0.0013**		
GDP_{t-4}	0.0036***		
FTE_{jt-2}		12.6641***	
$I_{2018,t}$			-4 439 847.5093***
$t \cdot I_{2018,t}$			2202.4593***
Constant	829.8248	-781.9559***	32 829.1930***
R^2	0.94	0.99	0.91
Adj. R^2	0.9149	0.9916	0.9014
N	22	22	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université Laval

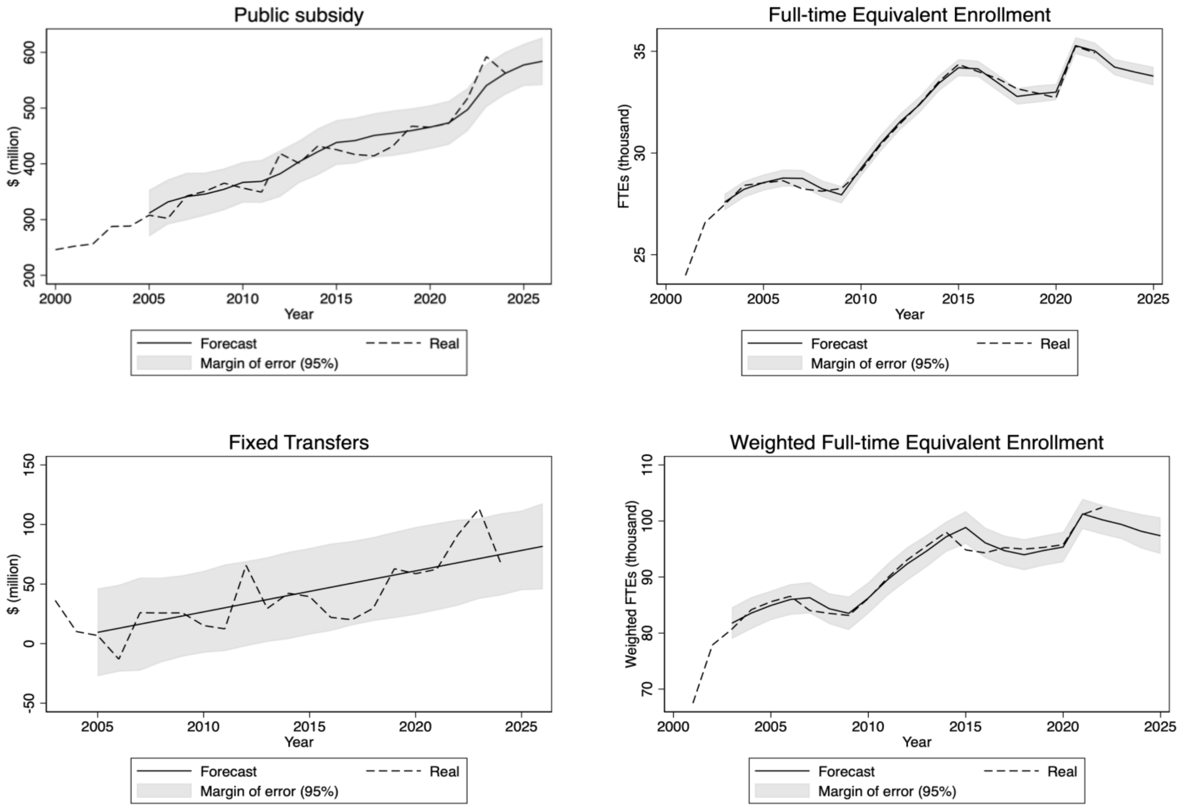

Figure B7. Graphical Forecasts for Université Laval

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B8. Estimated Model for Université Laval

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.3106***	-1.2210**	
FTE_{jt-2}		2.3539***	
u_{t-3}	886.9935***		
u_{t-4}	255.5024**		
pop_{t-2}	-0.0061*		
pop_{t-4}	0.0131***		
$immi_{t-2}$	-0.0738***		
$immi_{t-4}$	0.0822***		
FTE^{w}_{jt-3}		0.4960***	
t			3440.3974***
Constant	-42 082.7905***	10 663.7486**	-6 888 563.2270***
R²	0.99	0.96	0.56
Adj. R²	0.9914	0.9568	0.5425
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

École Polytechnique de Montréal

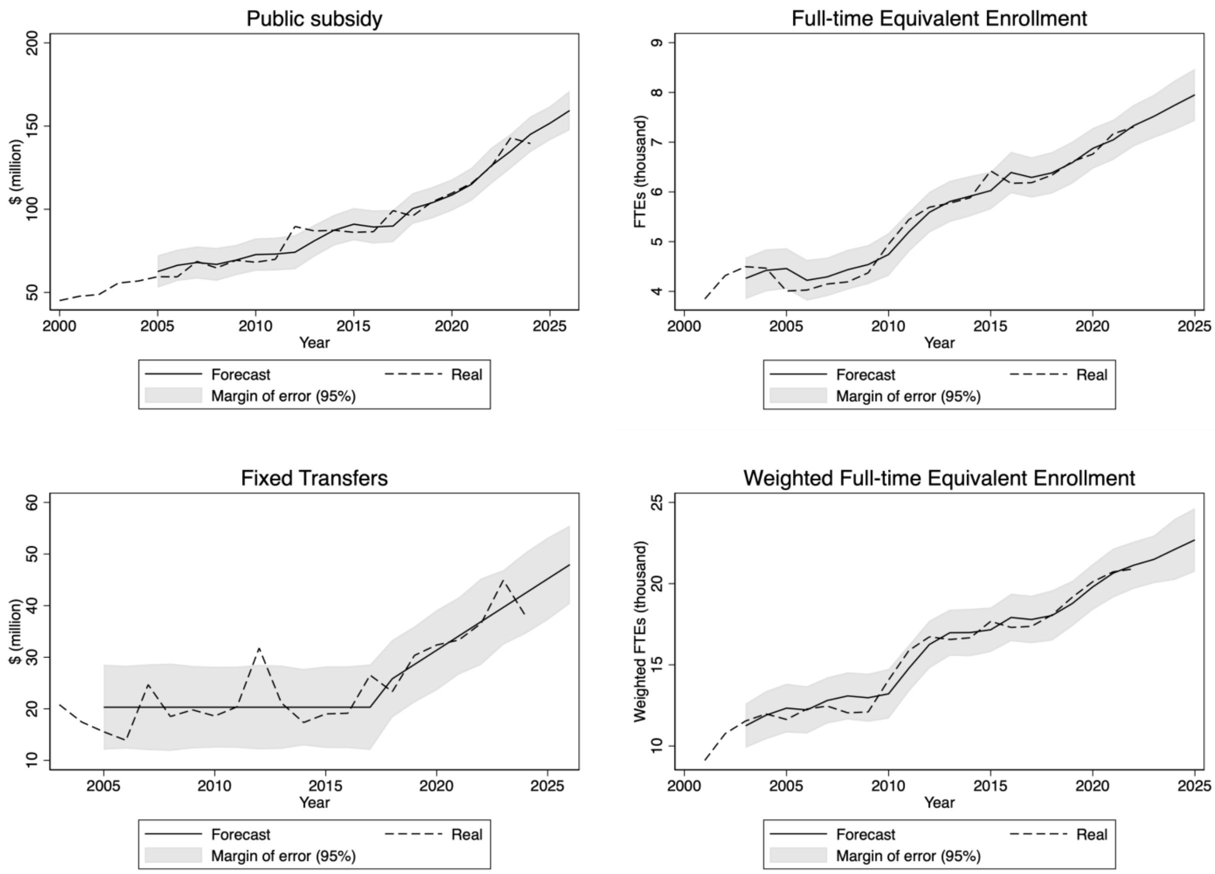

Figure B8. Graphical Forecasts for École Polytechnique de Montréal

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Table B9. Estimated Model for École Polytechnique de Montréal

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.6231***	-1.4739***	
FTE_{jt-2}		2.3184***	
pop_{t-3}	0.0011**		
FTE^{w}_{jt-3}		0.6999***	
$I_{2018,t}$			-55 72 050.6044***
$t \cdot I_{2018,t}$			2763.9124***
Constant	-6717.0124**	195.0449	20 307.0914***
R²	0.96	0.99	0.77
Adj. R²	0.9578	0.9878	0.7442
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Université de Sherbrooke

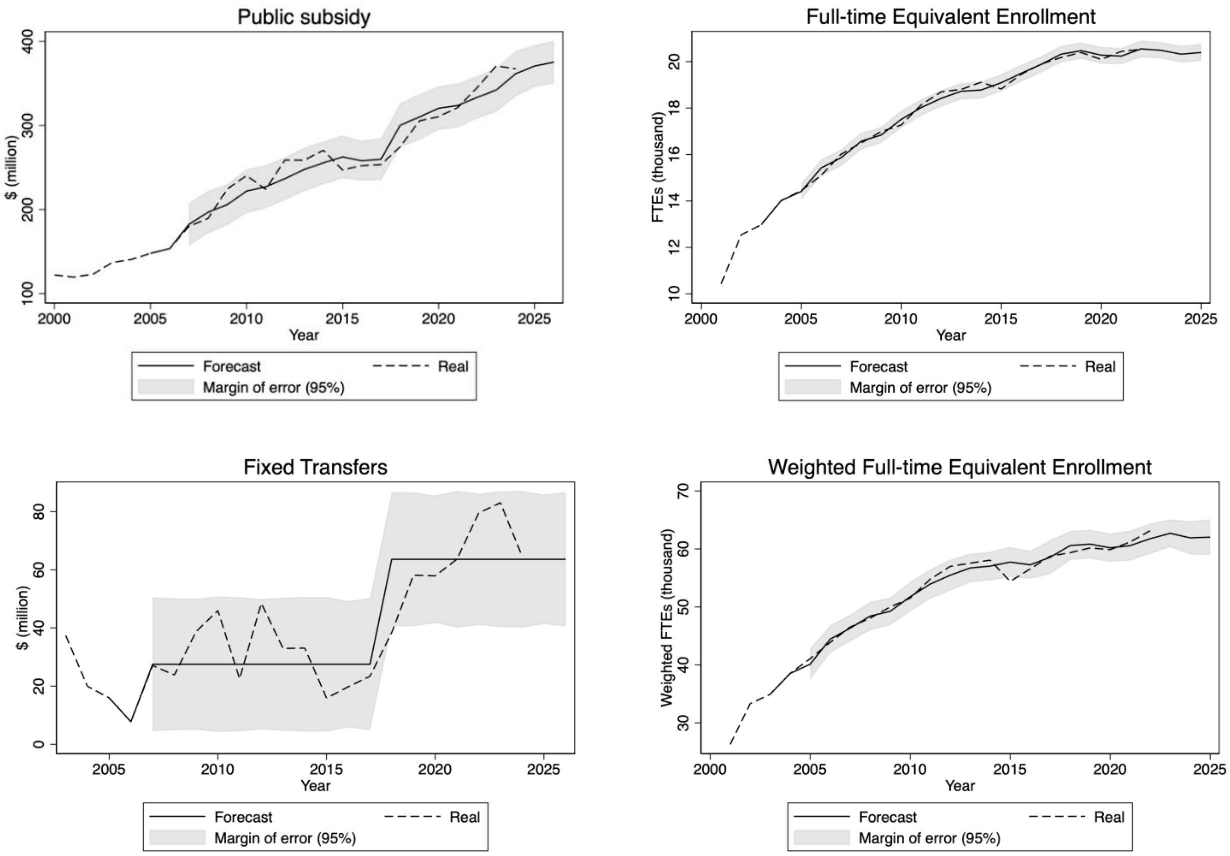

Figure B9. Graphical Forecasts for Université de Sherbrooke

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Table B10. Estimated Model for Université de Sherbrooke

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-6}	0.4342***		
FTE_{jt-3}		-2.5249***	
FTE_{jt-2}		3.5175***	
pop_{t-2}	0.0060***		
u_{t-2}	-291.3167***		
GDP_{t-2}	-0.0226***		
FTE^{w}_{jt-3}		0.7170***	
$I_{2018,t}$			36 081.3997***
Constant	-27 212.5311***	-2792.0930	27 533.5646***
R^2	0.99	0.99	0.66
Adj. R^2	0.9874	0.9916	0.6413
N	18	21	22

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Université TÉLUQ

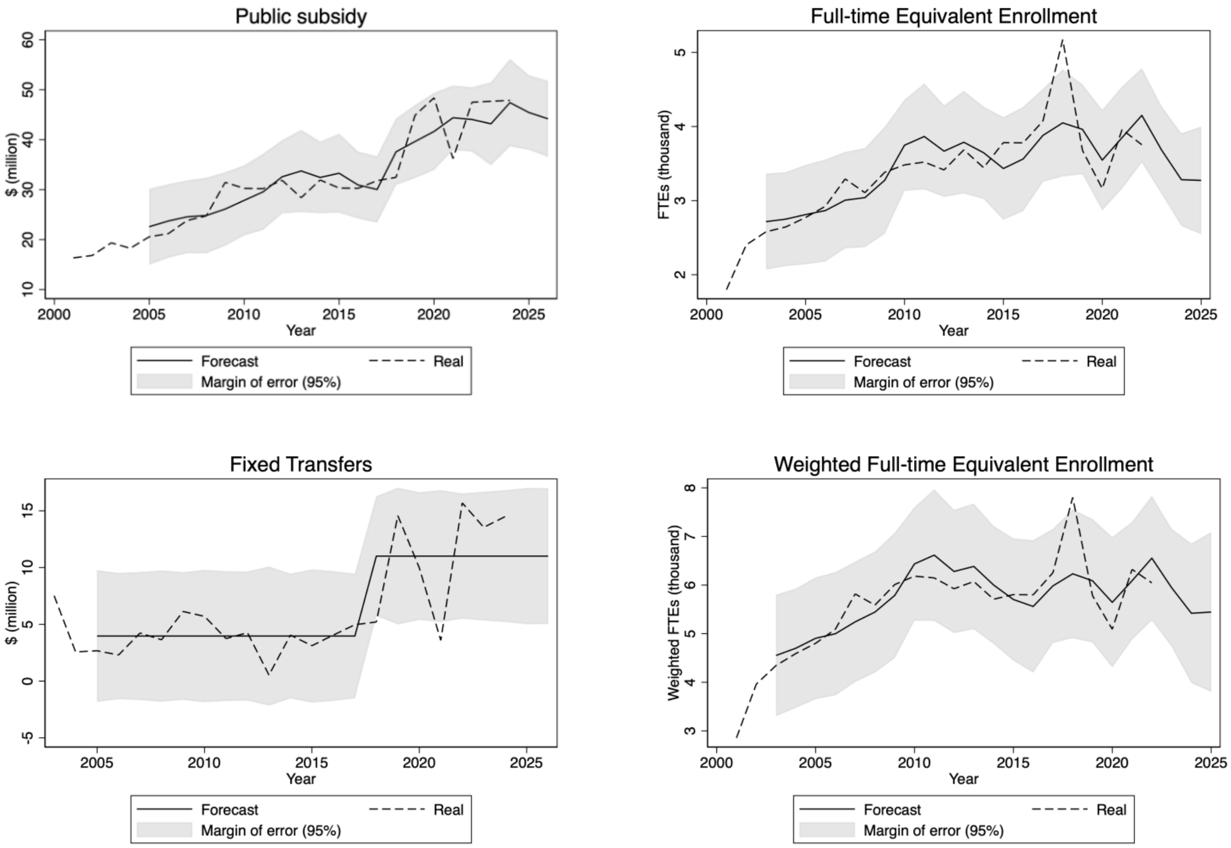

Figure B10. Graphical Forecasts for TÉLUQ

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B11. Estimated Model for TÉLUQ

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	-0.1053	-1.1583***	
FTE_{jt-4}	-0.1396		
FTE_{jt-2}		1.3308***	
pop_{t-2}	0.0089		
pop_{t-3}	-0.0048		
GDP_{t-3}	-0.0153		
$immi_{t-3}$	0.0256		
FTE^{w}_{jt-3}		0.8033***	
$I_{2018,t}$			7040.8641***
Constant	-24 532.8223	538.5393***	3968.0383***
R^2	0.64	0.98	0.56
Adj. R^2	0.4735	0.9785	0.5414
N	20	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université de Montréal

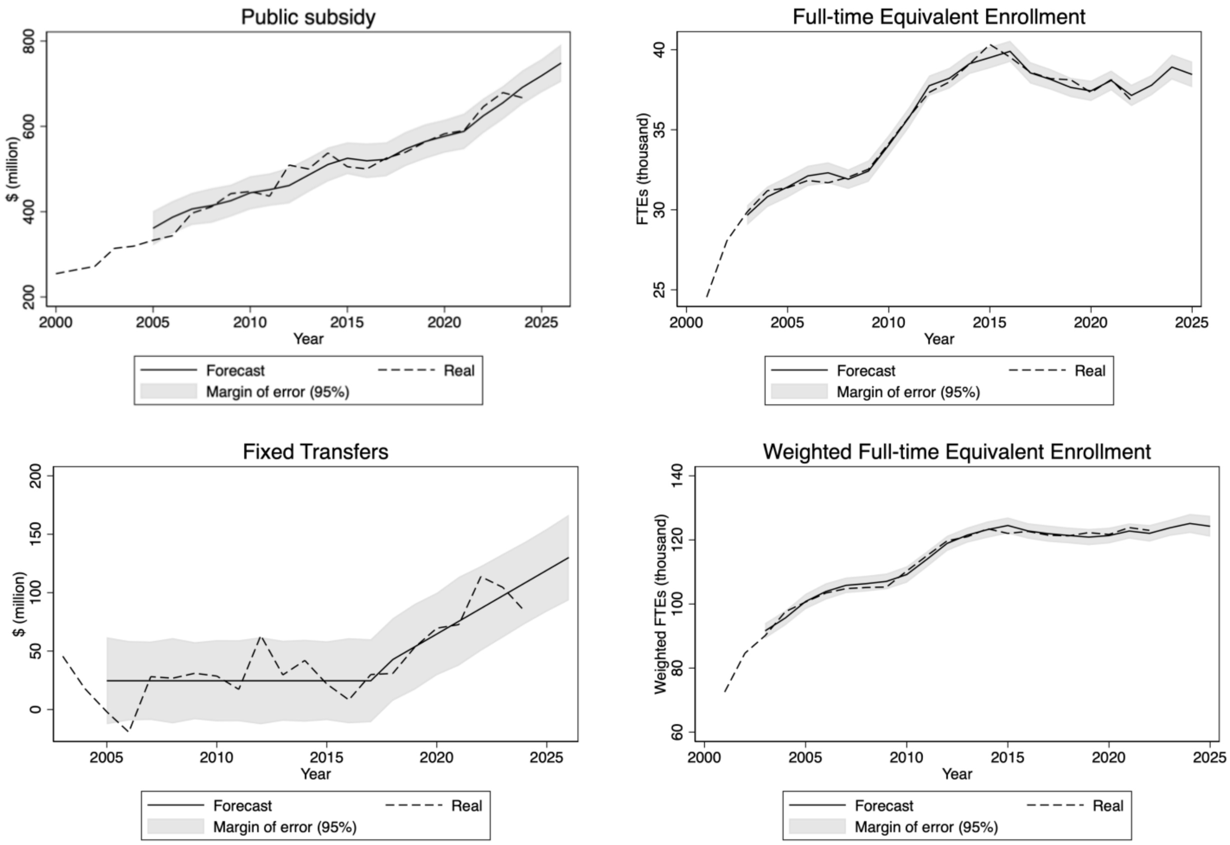

Figure B11. Graphical Forecasts for Université de Montréal

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B12. Estimated Model for Université de Montréal

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.7578***	-1.0257*	
FTE_{jt-4}	-0.2088*		
FTE_{jt-2}		1.5736***	
u_{t-3}	778.4300***		
pop_{t-4}	0.0032***		
$immi_{t-4}$	0.1936***		
FTE^{w}_{jt-3}		0.7392***	
$I_{2018,t}$			-2.2005e+07***
$t \cdot I_{2018,t}$			10913.4654***
Constant	-23 977.4415***	11 175.2397***	24 617.2500***
R^2	0.99	0.99	0.69
Adj. R^2	0.9869	0.9862	0.6614
N	20	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université du Québec à Montréal

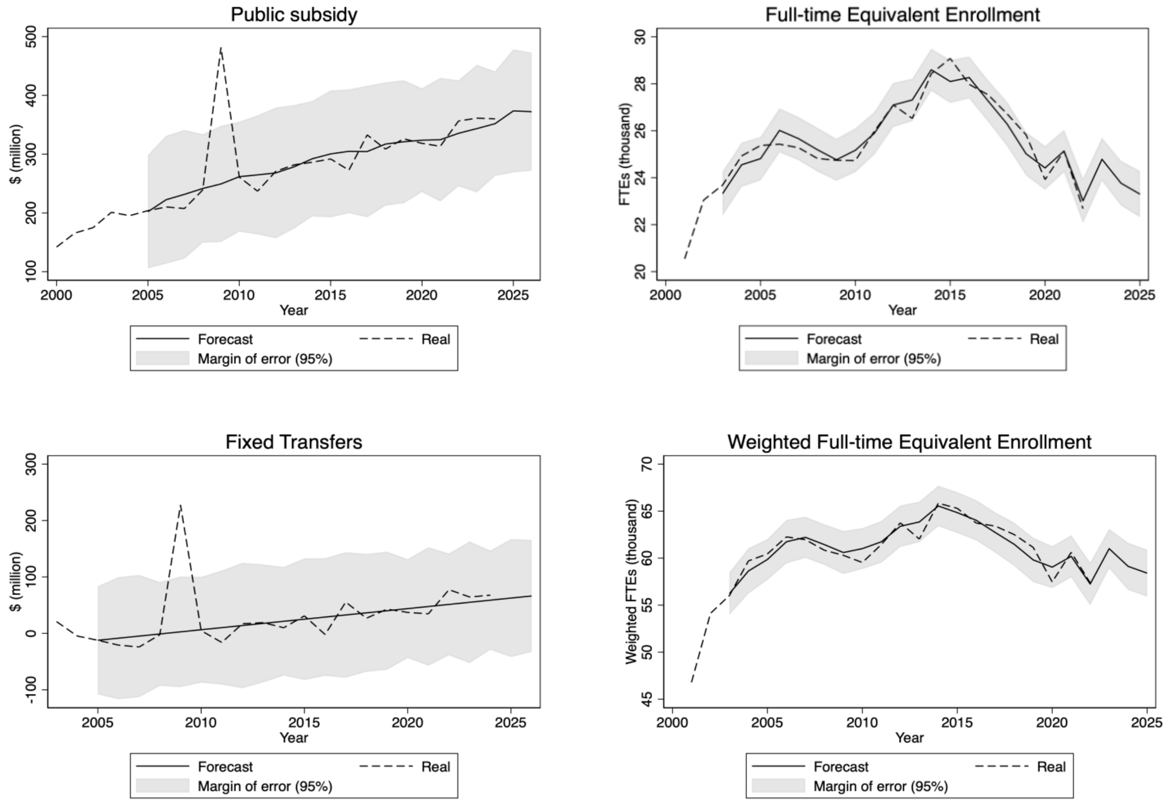

Figure B12. Graphical Forecasts for Université du Québec à Montréal

Notes: The fixed transfers for 2009 are considered an outlier when estimating the model.

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B13. Estimated Model for Université du Québec à Montréal

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-4}	0.4067***		
FTE_{jt-3}		-1.1655***	
FTE_{jt-2}		1.6206***	
u_{t-3}	625.1744**		
u_{t-4}	121.8740		
pop_{t-2}	-0.0140**		
pop_{t-4}	0.0136**		
$immi_{t-4}$	0.2144***		
FTE^{w}_{jt-3}		0.6097***	
t			3741.3103***
Constant	5043.6768	12 296.2739***	-7 513 607.8554***
R²	0.91	0.96	0.68
Adj. R²	0.8749	0.9481	0.6585
N	20	21	21

Notes: * p < 0.1, ** p < 0.05, *** p < 0.01

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université du Québec à Rimouski

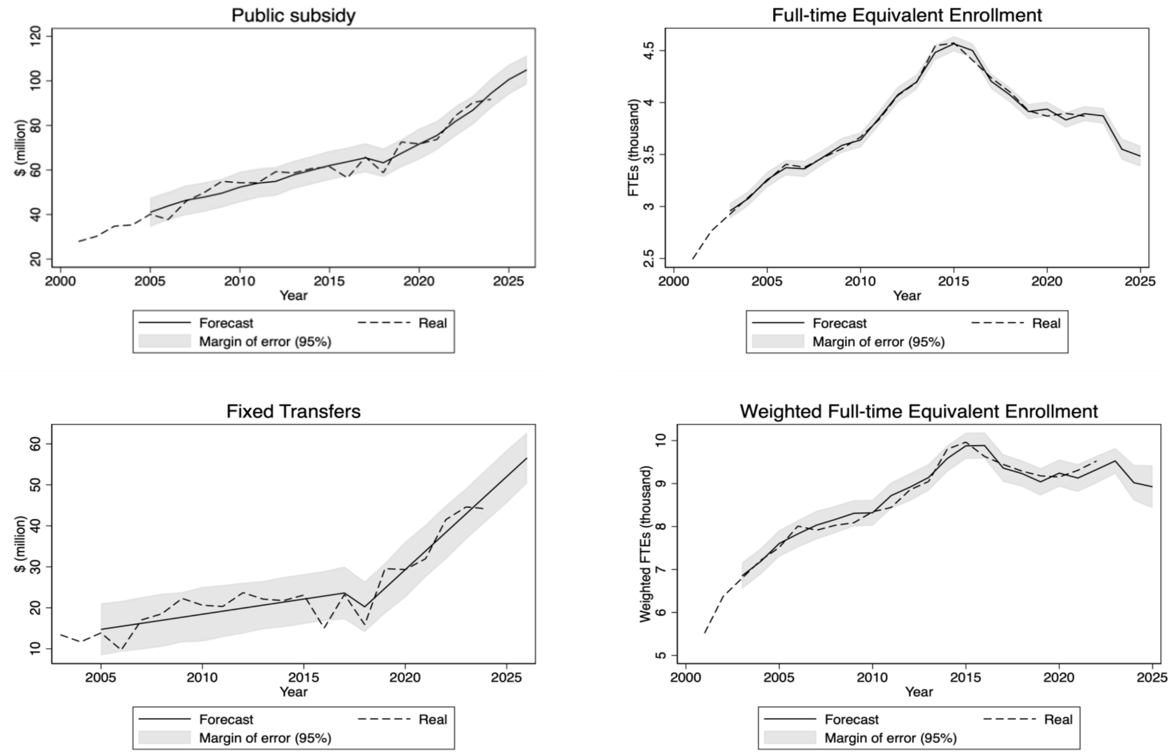

Figure B13. Graphical Forecasts for Université du Québec à Rimouski

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B14. Estimated Model for Université du Québec à Rimouski

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.8944***	-1.4632***	
FTE_{jt-4}	-0.4945***		
FTE_{jt-2}		1.5755***	
pop_{t-6}	0.0018***		
u_{t-6}	-161.9271***		
$immi_{t-4}$	0.0195***		
$immi_{t-6}$	0.0296***		
GDP_{t-6}	-0.0119***		
FTE^{w}_{jt-3}		0.9058***	
$I_{2018,t}$			-7 675 409.3016***
t			739.4846***
$t \cdot I_{2018,t}$			3801.4367***
Constant	-8933.9018***	461.5498	-1 467 929.4910***
R^2	0.99	0.98	0.90
Adj. R^2	0.9891	0.9820	0.8784
N	20	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université du Québec en Abitibi-Témiscamingue

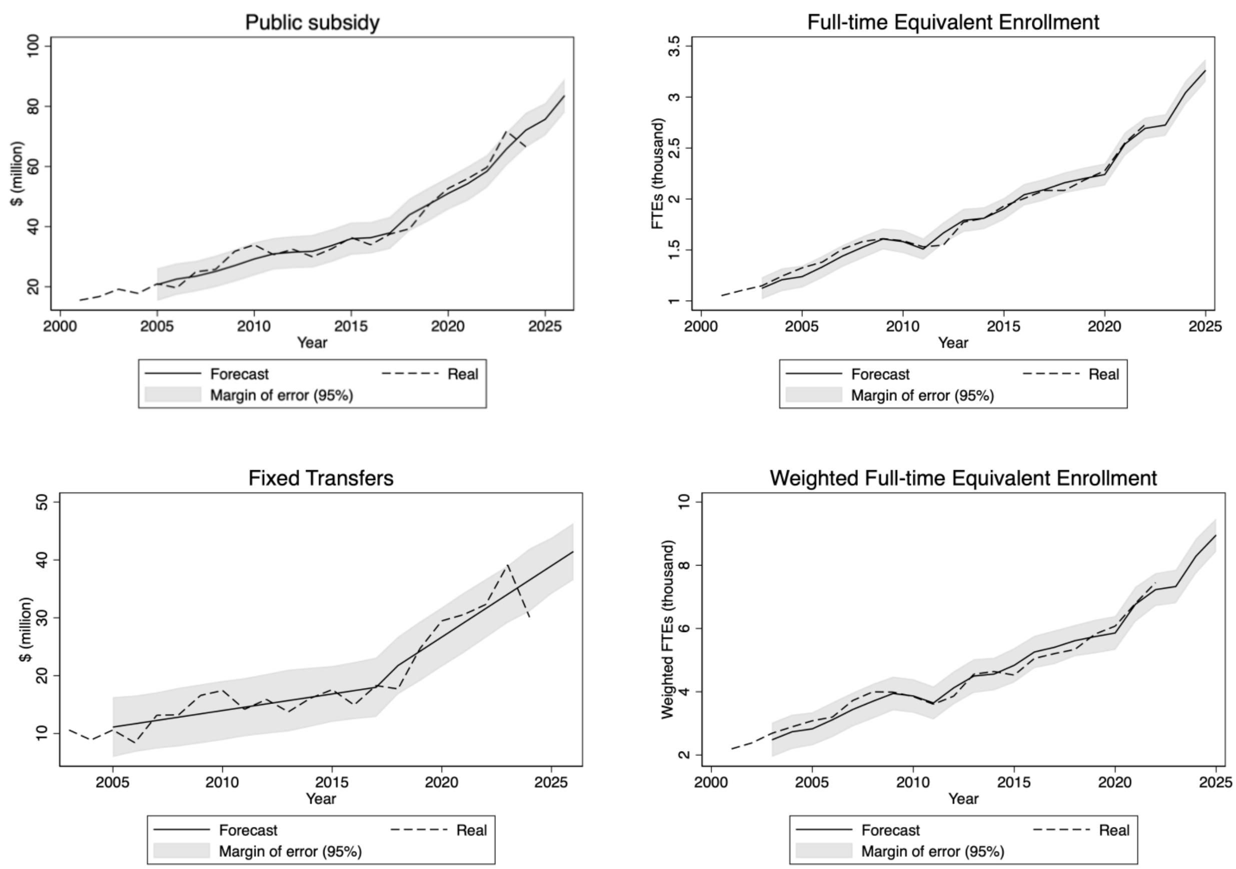

Figure B14. Graphical Forecasts for Université du Québec en Abitibi-Témiscamingue

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Table B15. Estimated Model for Université du Québec en Abitibi Témiscamingue

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
u_{t-2}	-46.2034*		
u_{t-3}	-101.8068*		
u_{t-4}	-82.1148**		
pop_{t-2}	-0.0008		
pop_{t-3}	-0.0014		
pop_{t-4}	0.0029*		
$immi_{t-2}$	0.0135*		
$immi_{t-4}$	-0.0123***		
FTE_{jt-2}		3.0285***	
$I_{2018,t}$			-3 811 932.5281***
t			572.5152***
$t \cdot I_{2018,t}$			1890.5471***
Constant	-2250.6353	-924.5168***	-1 136 783.0407***
R^2	0.99	0.99	0.90
Adj. R^2	0.9762	0.9915	0.8891
N	22	22	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author’s calculations and Ministère de l’Enseignement supérieurs (2000 to 2024a).

Université du Québec en Outaouais

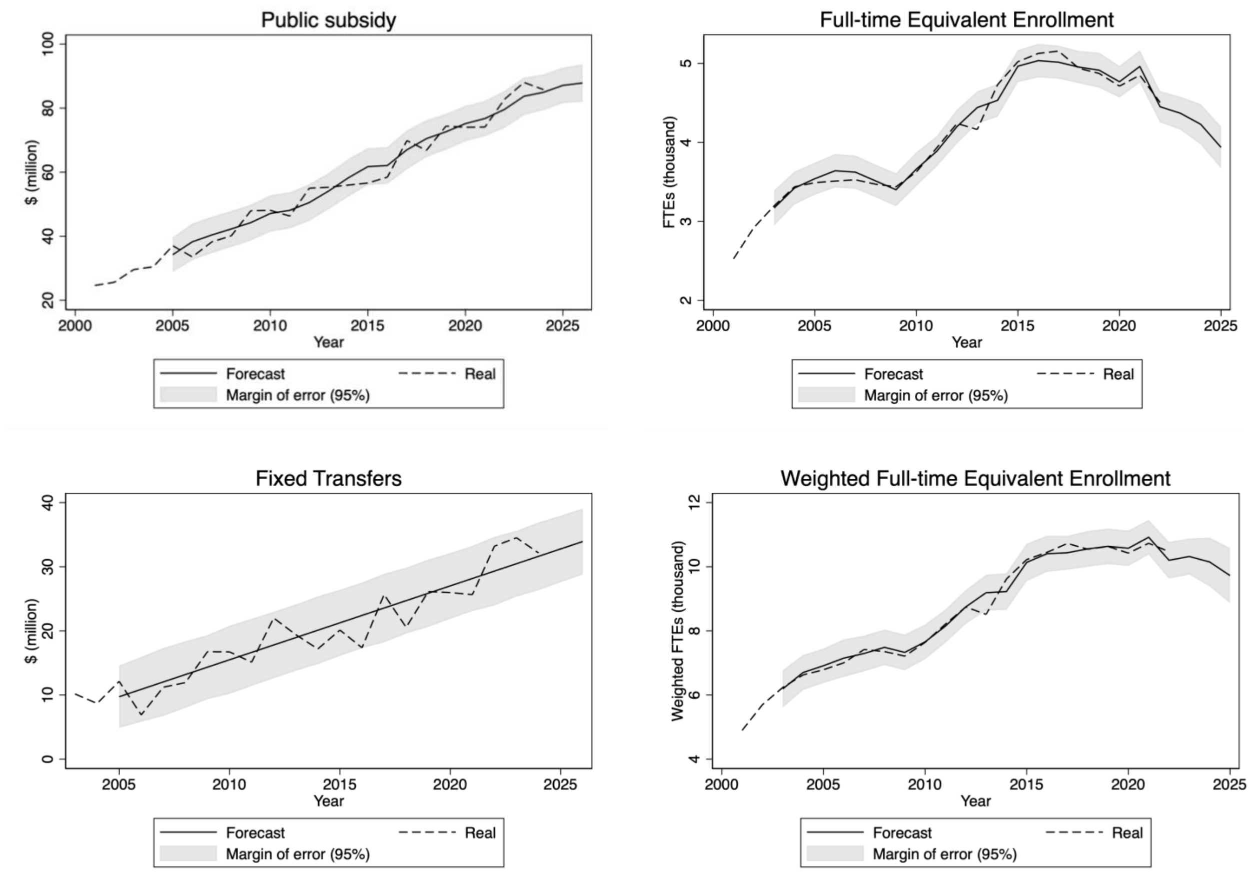

Figure B15. Graphical Forecasts for Université du Québec en Outaouais

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B16. Estimated Model for Université du Québec en Outaouais

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-3}	0.7563***	-1.4313***	
FTE_{jt-2}		1.5882***	
u_{t-3}	246.4930***		
pop_{t-4}	0.0007**		
$immi_{t-2}$	-0.0234***		
$immi_{t-4}$	0.0287***		
FTE^{w}_{jt-3}		0.9411***	
t			1152.3028***
Constant	-6286.1685***	-25.6486	-2 300 634.3482***
R^2	0.98	1.00	0.88
Adj. R^2	0.9712	0.9950	0.8777
N	21	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Université du Québec à Trois-Rivières

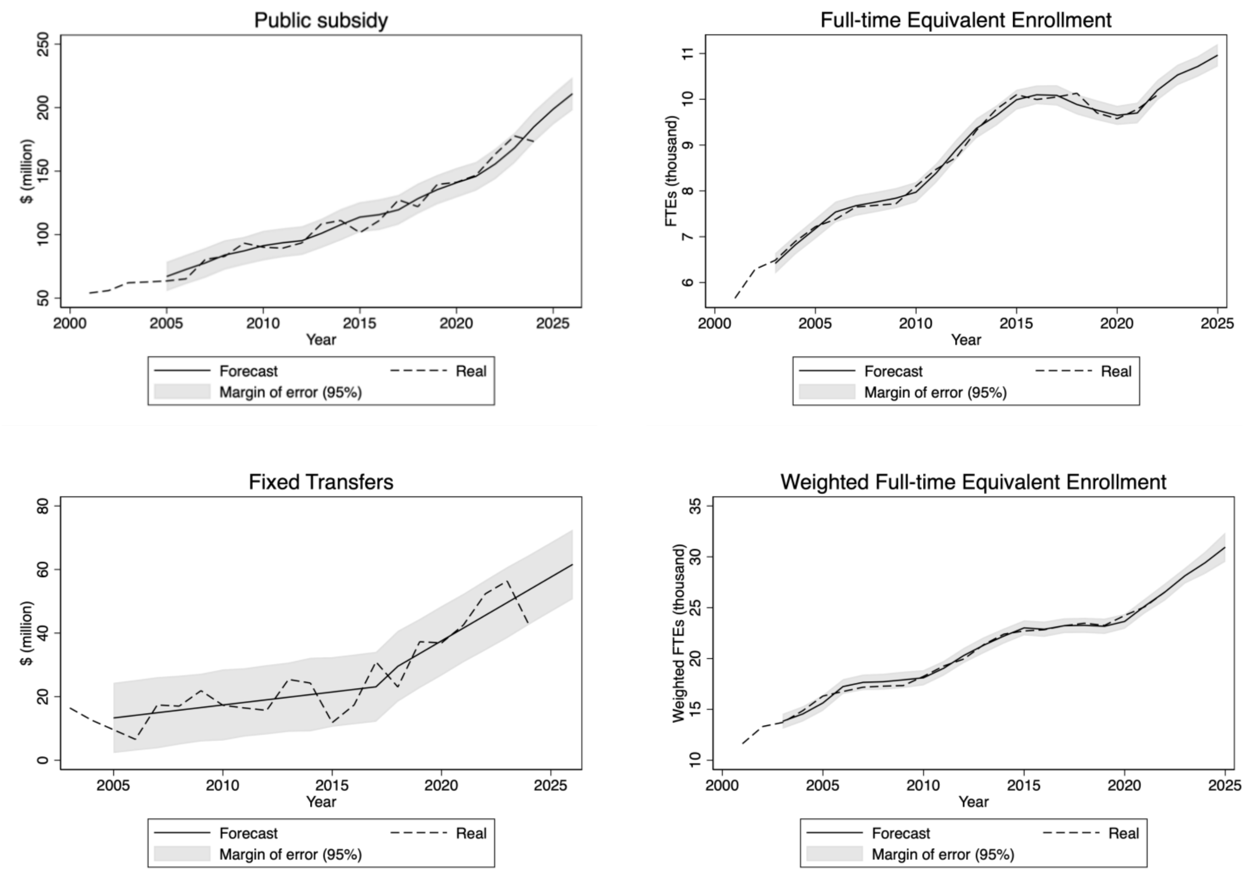

Figure B16. Graphical Forecasts for Université du Québec à Trois-Rivières

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Table B17. Estimated Model for Université du Québec à Trois-Rivières

	FTE_{jt-2}	FTE^{w}_{jt-2}	$T_{j,t}$
FTE_{jt-4}	0.5107***		
FTE_{jt-3}		-2.1139***	
FTE_{jt-2}		1.6119***	
pop_{t-2}	-0.0060***		
pop_{t-4}	0.0069***		
$immi_{t-3}$	0.0349***		
$immi_{t-4}$	0.0305***		
FTE^{w}_{jt-3}		1.1884***	
$I_{2018,t}$			-6 436 487.5345**
t			815.4074**
$t \cdot I_{2018,t}$			3192.3342**
Constant	-5349.1149***	966.2089	-1 621 578.6295**
R^2	0.99	0.99	0.84
Adj. R^2	0.9887	0.9923	0.8170
N	20	21	22

Notes: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Sources: Author's calculations and Ministère de l'Enseignement supérieurs (2000 to 2024a).

Appendix C

Linear VAR Forecasts

The actual and forecast values of full-time equivalent university student enrollment (FTE) are presented in thousands of students, while the university operating grant (funding) values are given in millions of dollars. An asterisk (*) next to an actual value indicates that this value is outside the margin of error of the modelled forecast.

Table C1 (full). Forecasts and Actual Values of Full-Time Equivalent University Student Enrollment (FTE)

University	Year	[lower margin, upper margin]	Actual	Forecast
QC	2018-2019	[219.71 ; 228.9]	223.72	224.31
	2019-2020	[220.00 ; 230]	220.28	225
	2020-2021	[222.00 ; 248]	230.08	235
	2021-2022	[224 ; 235]	224	229
HEC	2018-2019	[8.39 ; 9.21]	8.88	8.8
	2019-2020	[8.39 ; 9.19]	8.98	8.79
	2020-2021	[8.03 ; 9.25]	9.73*	8.64
	2021-2022	[8.73 ; 9.42]	9.06	9.07
ÉNAP	2018-2019	[0.58 ; 0.68]	0.61	0.63
	2019-2020	[0.52 ; 0.72]	0.63	0.62
	2020-2021	[0.42 ; 0.78]	0.66	0.6
	2021-2022	[0.35 ; 1.01]	0.71	0.68
ETS	2018-2019	[8.06 ; 8.51]	8.01*	8.29
	2019-2020	[7.86 ; 8.35]	7.76*	8.11
	2020-2021	[6.97 ; 8.9]	7.75	7.94
	2021-2022	[7.33 ; 7.98]	7.27*	7.65
INRS	2018-2019	[0.44 ; 0.48]	0.46	0.46
	2019-2020	[0.46 ; 0.51]	0.52*	0.48
	2020-2021	[0.44 ; 0.53]	0.45	0.48
	2021-2022	[0.46 ; 0.49]	0.45*	0.48
Poly	2018-2019	[6.15 ; 6.56]	6.46	6.36
	2019-2020	[6.66 ; 7.24]	6.76	6.95
	2020-2021	[6.56 ; 7.51]	7.17	7.03
	2021-2022	[7.09 ; 7.51]	7.31	7.30
Bishop’s	2018-2019	[2.07 ; 2.33]	2.29	2.2
	2019-2020	[2.09 ; 2.25]	2.19	2.17

	2020-2021	[1.91 ; 2.29]	2.31*	2.1
	2021-2022	[2.06 ; 2.30]	2.23	2.18
Concordia	2018-2019	[24.85 ; 26.64]	25.85	25.75
	2019-2020	[24.64 ; 26.26]	25.2	25.45
	2020-2021	[22.72 ; 28.35]	26.43	25.53
	2021-2022	[25.38 ; 26.64]	25.80	26.01
Laval	2018-2019	[32.37 ; 33.04]	32.95	32.71
	2019-2020	[32.75 ; 33.49]	32.72*	33.12
	2020-2021	[34.49 ; 36.14]	35.25	35.31
	2021-2022	[35.11 ; 36.45]	34.92*	35.78
UdM	2018-2019	[37.00 ; 38.3]	38.11	37.65
	2019-2020	[37.27 ; 39.76]	37.32	38.51
	2020-2021	[28.53 ; 45.19]	38.14	36.86
	2021-2022	[36.33 ; 38.34]	36.83	37.33
McGill	2018-2019	[22.93 ; 27.26]	26.4	25.09
	2019-2020	[24.50 ; 28.99]	26.37	26.75
	2020-2021	[18.91 ; 32.19]	27.65	25.55
	2021-2022	[25.65 ; 29.07]	27.25	27.36
Sherbrooke	2018-2019	[20.49 ; 21.77]	19.99	21.13
	2019-2020	[20.67 ; 22.07]	20.10*	21.37
	2020-2021	[22.30 ; 24.33]	20.44*	23.32
	2021-2022	[21.36 ; 22.73]	20.53*	22.05
UQ	2018-2019	[64.38 ; 67.17]	62.78*	65.77
	2019-2020	[61.29; 65.29]	60.65*	63.29
	2020-2021	[58.67 ; 64.77]	62.96	61.72
	2021-2022	[60.19 ; 64.29]	60.12	62.24
UQAT	2018-2019	[2.02 ; 2.17]	2.12	2.09
	2019-2020	[2.22 ; 2.37]	2.28	2.3
	2020-2021	[2.29 ; 2.63]	2.55	2.46
	2021-2022	[2.65 ; 2.81]	2.73	2.73

UQAC	2018-2019	[4.95 ; 5.06]	4.47*	5
	2019-2020	[4.87 ; 5]	4.23*	4.94
	2020-2021	[4.81 ; 5.05]	3.93*	4.93
	2021-2022	[3.92 ; 4.45]	4.05	4.19
UQAM	2018-2019	[24.80 ; 26.43]	25.17	25.61
	2019-2020	[24.48 ; 25.94]	23.92*	25.21
	2020-2021	[22.95 ; 25.74]	25.14	24.34
	2021-2022	[23.23 ; 25.25]	22.68	24.24
UQO	2018-2019	[4.60 ; 4.94]	4.87	4.77
	2019-2020	[4.50 ; 4.92]	4.71	4.71
	2020-2021	[4.03 ; 5.06]	4.85	4.55
	2021-2022	[4.32 ; 4.64]	4.51	4.48
UQAR	2018-2019	[3.82 ; 4.13]	3.86	3.97
	2019-2020	[3.87 ; 4.22]	3.87	4.05
	2020-2021	[3.66 ; 4.54]	3.9	4.1
	2021-2022	[3.87 ; 4.17]	3.87	4.02
UQTR	2018-2019	[9.68 ; 10.13]	9.54*	9.91
	2019-2020	[9.40 ; 9.9]	9.58	9.65
	2020-2021	[10.59 ; 11.59]	9.78*	11.09
	2021-2022	[9.69 ; 10.20]	10.09	9.95
TÉLUQ	2018-2019	[3.56 ; 4.44]	3.67	4
	2019-2020	[2.86 ; 3.75]	3.16	3.3
	2020-2021	[4.47 ; 6.77]	3.96*	5.62
	2021-2022	[3.33 ; 4.46]	3.75	3.90

Source: Author's calculations and Ministère de l'Enseignement supérieur(2024a)

Table C2 (full). Forecasts and Actual Values of University Operating Grants (Financing)

University	Year	[lower margin. upper margin]	Actual	Forecasts
QC	2020-2021	[3087.77 ; 3303.34]	3315.17*	3195.56
	2021-2022	[3101.00 ; 3349.00]	3647.91*	3225
	2022-2023	[2916.00 ; 3711.00]	3788.67*	3313
	2023-2024	[3752 ; 4196]	3996	3974
HEC	2020-2021	[79.29 ; 86.91]	89.17*	83.1
	2021-2022	[75.58 ; 85.50]	94.11*	80.54
	2022-2023	[75.58 ; 97.21]	103.48*	85.05
	2023-2024	[84.13 ; 101.93]	99.32	93.03
ÉNAP	2020-2021	[9.88 ; 13.37]	19.12*	11.62
	2021-2022	[9.48 ; 13.07]	21.11*	11.28
	2022-2023	[9.20 ; 12.87]	21.78*	11.03
	2023-2024	[12.30 ; 16.35]	24.61*	14.32
ETS	2020-2021	[115.12 ; 133.44]	117.13	124.28
	2021-2022	[114.95 ; 130.83]	126.8	122.89
	2022-2023	[94.36 ; 144.05]	133.28	119.21
	2023-2024	[115.63 ; 128.92]	135.04	122.13
INRS	2020-2021	[55.35 ; 60.07]	65.05*	57.71
	2021-2022	[57.87 ; 63.17]	69.62*	60.52
	2022-2023	[60.28 ; 75.36]	70.8	67.82
	2023-2024	[68.42 ; 75.58]	72.11	72.00
Poly	2020-2021	[96.43 ; 105.54]	115.69*	100.99
	2021-2022	[103.66 ; 113.49]	123.02*	108.57
	2022-2023	[99.92 ; 135.82]	131.29	117.87
	2023-2024	[138.96 ; 154.43]	139.51	146.69
Bishop’s	2020-2021	[24.88 ; 30.62]	30.02	27.75
	2021-2022	[27.38 ; 32.72]	34.33*	30.05
	2022-2023	[20.92 ; 41.49]	32.55	31.21
	2023-2024	[35.41 ; 41.98]	38.07	38.41
Concordia	2020-2021	[261.87 ; 302.52]	286.68	282.19

	2021-2022	[234.94 ; 259.95]	324.81*	247.45
	2022-2023	[185.79 ; 292.54]	330.97*	239.16
	2023-2024	[246.95 ; 285.23]	335.11*	266.09
Laval	2020-2021	[441.06 ; 472.48]	472.73*	456.77
	2021-2022	[451.99 ; 483.50]	508.03*	467.74
	2022-2023	[451.99 ; 539.59]	546.54*	481.83
	2023-2024	[566.15 ; 629.94]	563.49*	598.05
UdM	2020-2021	[545.13 ; 582.13]	590.07*	563.63
	2021-2022	[563.80 ; 605.16]	635.01*	584.48
	2022-2023	[468.70 ; 729.09]	651.88	598.89
	2023-2024	[655.58 ; 714.53]	667.43	685.06
McGill	2020-2021	[317.73 ; 373.31]	403.78*	345.52
	2021-2022	[347.86 ; 397.62]	414.00*	372.74
	2022-2023	[290.54 ; 482.71]	436.32	386.63
	2023-2024	[450.24 ; 505.74]	454.44	477.99
Sherbrooke	2020-2021	[281.27 ; 305.10]	321.49*	293.27
	2021-2022	[289.99 ; 311.58]	335.19*	300.79
	2022-2023	[236.06 ; 360.70]	344.49	298.38
	2023-2024	[314.88 ; 348.47]	367.42*	331.67
UQ	2020-2021	[933.59 ; 991.84]	1005.54*	962.71
	2021-2022	[907.48 ; 982.51]	1104.27*	945
	2022-2023	[819.47 ; 1042.24]	1136.82*	930.86
	2023-2024	[1059.19 ; 1201.24]	1179.08	1130.22
UQAT	2020-2021	[44.08 ; 48.89]	55.95*	46.49
	2021-2022	[47.98 ; 53.16]	57.41*	50.57
	2022-2023	[48.26 ; 62.37]	62.99*	55.31
	2023-2024	[64.20 ; 73.82]	66.82	69.01
UQAC	2020-2021	[80.66 ; 88.29]	87.03	84.48
	2021-2022	[82.49 ; 90.29]	96.93*	86.39
	2022-2023	[79.11 ; 98.80]	97.66	89.00

	2023-2024	[88.69 ; 101.72]	100.57	95.20
UQAM	2020-2021	[278.55 ; 299.14]	313.35*	288.84
	2021-2022	[265.65 ; 290.01]	348.88*	277.83
	2022-2023	[199.62 ; 300.83]	350.63*	250.23
	2023-2024	[277.32 ; 328.83]	360.15*	303.08
UQO	2020-2021	[66.96 ; 74.26]	74.1	70.61
	2021-2022	[67.21 ; 73.92]	80.70*	70.57
	2022-2023	[67.21 ; 79.97]	85.11*	67.62
	2023-2024	[70.13 ; 78.73]	86.00*	74.43
UQAR	2020-2021	[59.85 ; 65.98]	73.78*	62.92
	2021-2022	[57.91 ; 64.50]	82.45*	61.2
	2022-2023	[47.04 ; 76.07]	87.21*	61.55
	2023-2024	[59.14 ; 69.77]	92.10*	64.46
UQTR	2020-2021	[129.61 ; 139.98]	146.73*	134.8
	2021-2022	[129.10 ; 143.37]	158.51*	136.23
	2022-2023	[125.74 ; 157.12]	163.37*	141.43
	2023-2024	[168.58 ; 188.81]	173.14	178.70
TÉLUQ	2020-2021	[43.87 ; 54.54]	36.21*	49.2
	2021-2022	[32.47 ; 37]	46.06*	34.73
	2022-2023	[13.99 ; 44.66]	47.53*	29.33
	2023-2024	[27.24 ; 42.82]	47.96*	38.54

Source: Author’s calculations and Ministère de l’Enseignement supérieur (2024a)