STATISTICS

Dalarna University

Short-term Forecasting of Reimbursement for Dalarna University

One year master thesis in statistics 2008

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Abstract

Swedish universities are reimbursed by the government according to a scheme related to the registration of students (HSTK) and the students' performance (HPRK). On a disaggregated level, such as a department or a field, the reimbursement is uncertain as the number and performance of students are fluctuant. So the administration faces the challenge to balance the reimbursement and the expense. In this thesis, we try to distinguish a better forecasting model for the educational fields or the departments of Dalarna University. We analyze the time series by two methods, namely Census II method and the ARIMA method. We apply the two methods to two approaches, direct and indirect approaches. The first one is to use the time series of reimbursement directly; the second one is to forecast the number of students and their performance separately, and then convert these two forecasted values into reimbursement. To compare the results, we choose the indication of MAPE. We use monthly data from Jan. 2000 to Feb. 2008. Finally, we find that, on the department level, the ARMA model of the indirect approach is the best one for forecasting the reimbursement.

Keywords: Census II Method, ARMA Method, MAPE

Contents

1. Introduction

In Sweden, the reimbursement for the higher education sector is always increasing until recently. In 2004, the reimbursement became to decline partly because the educational institutions enrolled less students than before[1] as the reimbursement is highly related to the number and the performance of the college students. To some extent, the reimbursement for a university will fluctuate around a trend. Our thesis is to establish an accurate model to forecast the reimbursement for the fields or the departments in the university. The model may help them to balance their expense and reimbursement better. In this thesis, we take the Dalarna University as an example.

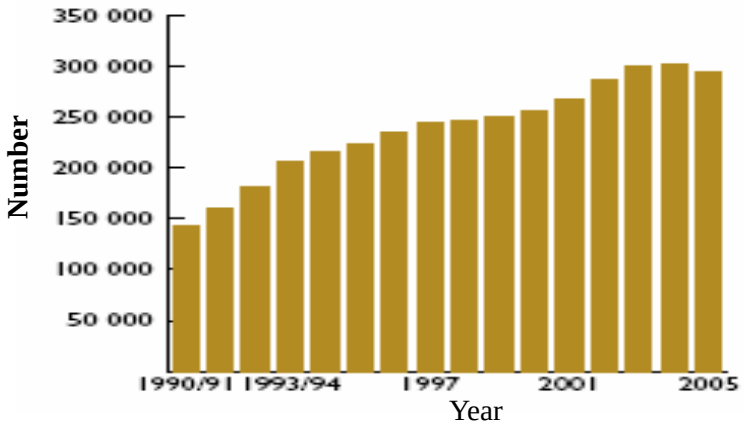

Figure 1: The number of full time equivalent (FTE) students in Sweden
Source: 2005 Annual Report of Swedish National Agency for Higher Education

Figure 1 shows the number of students registered in 1990-2005. In 2005, the total volume of higher education comprised 295,150 full-time students. This is a reduction of 2.5 percent compared with the previous year and this is the first time for twenty years that the number of full-time students declined[2].

Dalarna University was established in 1977. Today there are about 10 000 students studying

[1] http://hsv.se/statistics/theannualreport.4.539a949110f3d5914ec800064188.html
[2] http://www.hsv.se/download/18.539a949110f3d5914ec800081527/0638R.pdf

in this university. Distance education is also offered in various forms. There are more than 200 courses within the areas of welfare, business, infrastructure media, culture and tourism and so on[3]. All of the courses are classified into 11 fields: the Humanity, Sport, Law, Education, Media, Medicine, Natural Science, Social Science, Technique, Health and Care, and the Others, the amount of the reimbursement depends on these fields. The courses can also be classified into 5 departments: Culture, Social, Health, Humanity, and Industry. The fields and the departments at Dalarna University are shown in Table 1.

Table 1: The share of the fields and departments in terms of the average reimbursement from 2000 to 2008 (%)

Department / Field	Culture	Social	Health	Humanity	Industry	Marginal size
Other	8.59	0.01	6.56	3.80	2.63	2.21
Humanity	5.39	0.14	0.76	55.60	0.27	7.33
Sport	-	1.21	1.71	-	-	0.48
Law	-	13.07	16.90	-	-	1.76
Education	0.83	1.96	20.86	38.96	2.69	12.00
Media	-	10.47	22.82	-	-	16.80
Medicine	31.31	-	-	-	-	4.45
Natural Science	2.54	17.01	3.16	0.95	56.04	11.90
Social Science	11.10	42.84	19.31	1.06	-	10.90
Technique	45.89	22.05	-	-	40.01	21.70
Care	0.72	1.18	16.83	-	-	10.40
Marginal size	17.10	14.60	39.70	11.80	16.80	100.00

This table shows the size each field takes up in the departments and the marginal size of the departments and the fields in Dalarna University. For example the field Humanity takes up 5.39 % in the Culture department, and about 7.33 % in this school and the Culture department takes up 17.1 %. From this table we can see the Sport field is the smallest one, whereas the

[3] http://du.se/Templates/StartPage____1622.aspx?epslanguage=SV

Technique field is the largest one.

The key of this thesis is that we classified the data not only by the fields, but also by the departments. To forecast the reimbursement, we choose two approaches: the direct approach and the indirect approach. The first one is to use the time series of the reimbursement directly; the second one is to forecast the number of students and their performance separately and then convert these forecasted values into the reimbursement. We use two methods, namely the Census II method and the ARIMA method, to model these two approaches on the field level and the department level.

2. Data Description

We use the monthly data from Jan. 2000 to Feb. 2008. The Swedish universities are reimbursed by the government according to a simple scheme related to the registration of the students and the student's performance. The allocation rule of the reimbursement is: 60% of the reimbursement is based on the registration and 40% is based on the performance[4]. In this thesis, we use HSTK as the short form for the registration of the students and HPRK for the performance. We get the data of HSTK and HPRK from all the courses. All the courses are classified into 11 fields and how the reimbursement depends on fields is shown in the table A and B of the Appendix C. The HSTK is calculated by the number of registered students multiplying with the credits of the course and dividing by 60 credits which is the total number of credit points for one year full-time study. The calculating method of the HPRK is similar to the HSTK. The only difference is the number of registered students is changed into the number of students who have passed the examination. The two formulations are shown below:

HSTK = number of registered students ×credits of the course /60

HPRK = number of students who have passed the exam ×credits of the course /60

[4] The Annual Report of Swedish National Agency for Higher Education
http://hsv.se/statistics/theannualreport.4.539a949110f3d5914ec800064188.html

We received the data saved in 9 Excel files, which present the 9 years from 2000－2008, and each file contains 12 spreadsheets presenting the 12 months of the year. In each row of the spreadsheet, it lays out the records of the HSTK and HPRK for each course offered by the university.

- **Data classified by fields**

To arrange the data, we merged the records of the courses which belong to the same field in every month by summing these records and named them as THSTK and THPRK. Because the records are accumulative, to get the value of the HSTK and the HPRK happened in this month we should use the one month later data subtract the data of this month. For example, when we calculate the HSTK in the field of Natural Science (NAT) in December 2007, we should use the formulation: $\mathrm{THSTK}_{2007,12} - \mathrm{THSTK}_{2007,11} = 505.5049 - 502.7699 = 2.735$. To calculate the HPRK in the same field in December 2007, we should use the formulation: $\mathrm{THPRK}_{2007,12} - \mathrm{THPRK}_{2007,11} = 366.1825 - 320.91 = 45.2725$. With the number of the HSTK and the HPRK of each month in hand, we can convert these values into the monthly reimbursement with the following function:

$$\begin{aligned}\text{Reimbursement} &= 19465 * (\mathrm{THSTK}_t - \mathrm{THSTK}_{t-1}) + 17085 * (\mathrm{THPRK}_t - \mathrm{THPRK}_{t-1}) \\ &= 19465 * 2.735 + 17085 * 45.2725 = 826717.438\end{aligned}.$$

Where t represents the months, the 19465 presents the reimbursement for each unit of the HSTK in the field of Natural Science and the 17085 is for each unit of the HPRK, which is shown in Appendix C. The annual total reimbursement of the university is shown in Table 2.

Table 2: The annual reimbursement of Dalarna from 2000-2007 (Million SEK)

2000	2001	2002	2003	2004	2005	2006	2007
323.923	315.706	379.360	417.720	380.854	373.210	387.713	390.240

This information presents the trend of the reimbursement, and we can see the fluctuation of the reimbursement during the years. For example in year 2004 the reimbursement is 380.854

million SEK.

- **Data classified by departments**

In the original data, we do not have the level of the reimbursement for departments. To calculate the reimbursement of each department, firstly we merged the records of the courses which belong to the same department in every month, and then in each department we merged the records of the courses which belong to the same field. After these procedures, with the same calculating method for the field just as we stated above, we can get the reimbursement of the department. Then we got the true value happened in every month. Then we had monthly time series data for 9 years for each of the departments.

3. Method

To forecast the reimbursement for one field or one department, we consider two approaches, namely indirect and direct approaches. The reimbursement is determined in a simple way. Let y be the reimbursement of one field or one department, z denotes the number of the HSTK, and w denotes the number of the HPRK. Then we have the formulation:

$$y_t = c_1 * z_t + c_2 * w_t \quad (1).$$

Where the constants c_1 and c_2 are the reimbursement depending on the field and shown in Appendix C. The direct approach is to model $\hat{y}_t$ directly, where $\hat{y}_t$ is a function of past value of y say $y_t, y_{t-1}\ldots\ldots$, and time $t, t-1\ldots\ldots$. For the indirect method, first we forecast the z_t and w_t separately, which means we build one model for $\hat{z}_t$, a function of $z_t, z_{t-1}\ldots\ldots, t, t-1\ldots\ldots$ and one for the $\hat{w}_t$, a function of $w_t, w_{t-1}\ldots\ldots, t, t-1\ldots\ldots$ then convert the two forecasted values into reimbursement calculated by equation (2).

$$\hat{y}_t = c_1 * \hat{z}_t + c_2 * \hat{w}_t \quad (2).$$

Where the "Λ" means the predicted value. To get the model we choose the Census II

method and the ARIMA method.

Firstly, we introduce the knowledge of the Census II method. Any time series X is composed of trend (T), season (S), cycle (C), and random influences (E). This method is to derive the trend, season, and other components from X. There are two common models:

Multiplicative: $X = （T \times C）\times S \times E$

Additive: $X = （T + C）+ S + E$

In this thesis we choose the additive method, because the multiplicative model is commonly used for the growth curve rather than stationary curve. Another reason why we choose the additive model is that the original data contains the 0 value, which can not be transacted by the multiplicative model. The main step of the Census II is computing T+C by moving average and then get S+E=X-(T+C). Then get S by moving average and calculate X-S = T+C+E, the seasonal adjusted value. In this process, we use the moving average many times. Finally we can calculate the value of $\hat{X}_t$: $\hat{X}_t = \hat{T} + \hat{C} + \hat{S}$. All these steps are performed with statistic software Eviews 3.

We also tried the ARIMA model (Autoregressive Integrated Moving Average model). The main procedure of this model is explained as follow: when we get the observed series, the first thing is to decide if the series is stationary. We use the test of unit root to test if the series is stationary. We found that the data is stationary and hence we need not to difference the series. Then we can construct an ARMA model, and check whether the residuals of the ARMA model are white noise. If not, we repeat the procedure above, if so, the procedure is over.

4. Results for the Field of Natural Science

There are 11 fields and 5 departments in Darlarna University and it would be too many to show all the results. Instead we will describe the modeling process of the field of Natural Science as an example. The proceeding is similar for the other fields and the departments. Summary results are given in sections 5 and 6.

After removing the seasonal factor, we get the seasonal adjusted series of the HSTK in the field Natural Science**.**

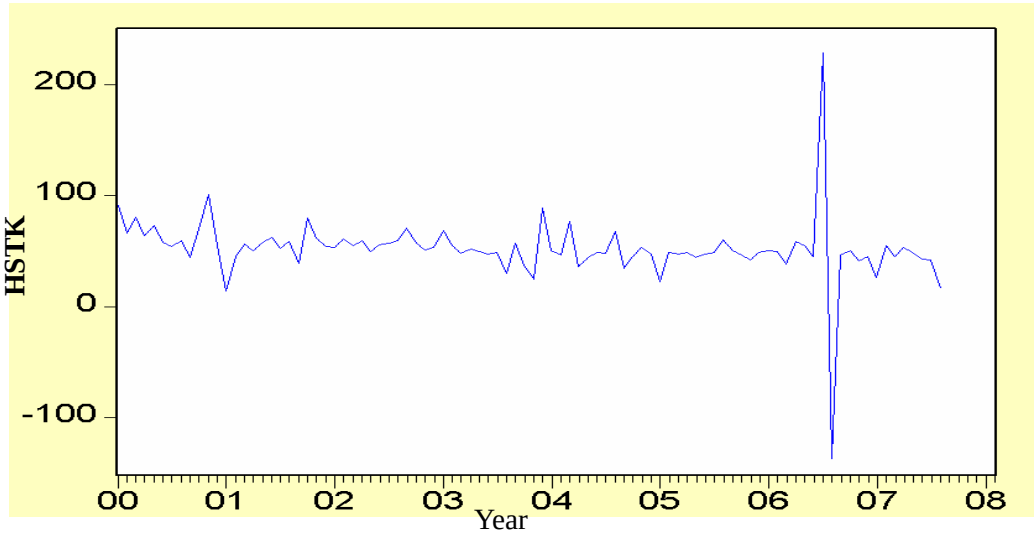

Figure 2: Seasonal adjusted series of the registration in the field Natural Science

Let z_t^* be the seasonal adjusted series. We try several functions to model z_t^*, such as the error function, logistic transform, linear function of t and t ^n and log function and so on. In Table 3 we show the AIC for some competing models.

Table 3: The Values of AIC for competing models

Function	AIC
Error Function	9.55
Logistic Transform	9.58
Linear Function of t and t^ n	9.89
Log Function	9.85

According to AIC, we would like to choose the Error Function:

$$\hat{z}_t^* = b * \frac{2}{\sqrt{\pi}} \int_0^t e^{-z^2} dz + MA(1)$$

This is a function of $\hat{z}_t^*$ and t; b is a parameter to be estimated. The residuals of the model pass the white noise test. So the model is reasonable. Then we show the graph of seasonal

factor in Figure 3:

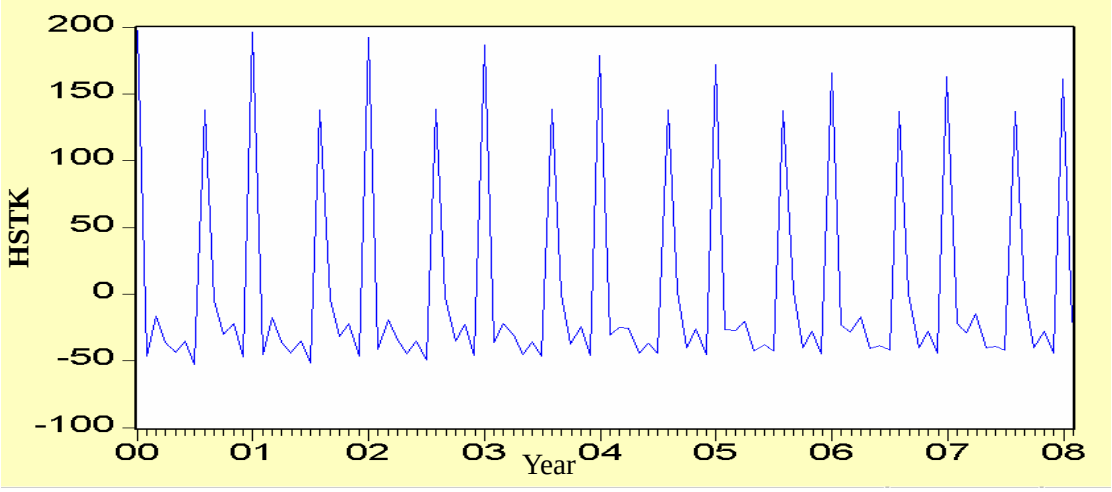

Figure 3: Seasonal factor series of the registration in the field Natural Science

Let z_t' be the seasonal factor series. According to the formulation:

$$\hat{z}_t = \hat{z}_t^{*} + \hat{z}_t' \qquad (3)$$

So we can calculate the value of the $\hat{z}_t$. Figure 4 shows linear graph of the forecasted data and the original data.

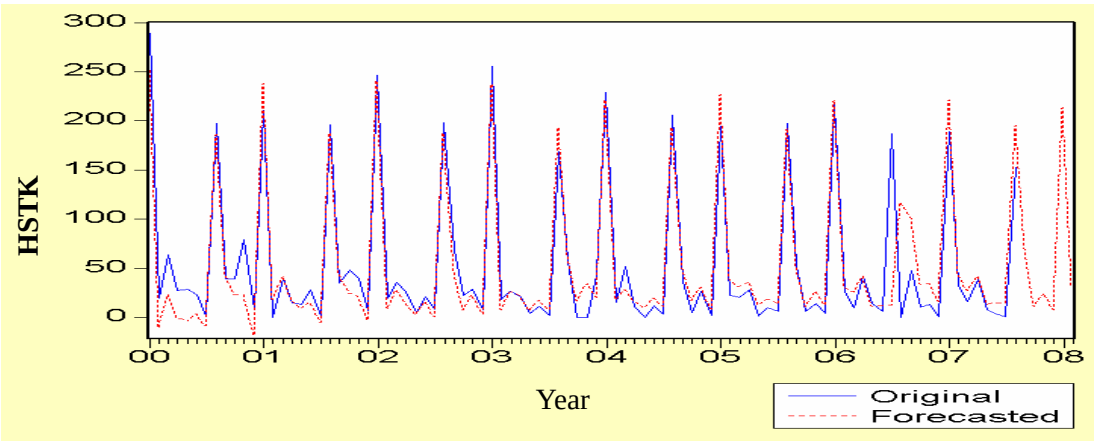

Figure 4: Comparison between original value and forecasted value of the registration in the field Natural Science

The correlation of $\hat{z}_t$ and z_t is 0.92. We also check the index of mean absolute

percentage error (known as $\text{MAPE} = \frac{\sum_{t=1}^{n} |\hat{z}_t - z_t| / z_t}{n} * 100\%$). When n=6, it equals to 22.66 %.

The analysis of the HPRK is similar as the HSTK. Let w_t^* be the seasonal adjusted series, w_t' be the seasonal factor series. The graph of seasonal adjusted is shown below:

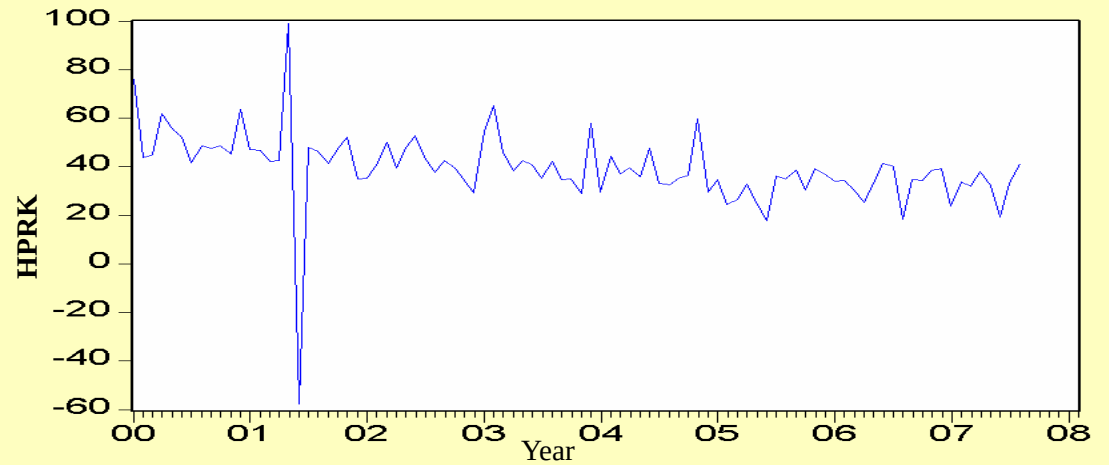

Figure 5: Seasonal adjusted series of performance in the field Natural Science

The result is quite similar as the HSTK. According to AIC, we still choose the error function. Then we show the graph of seasonal factor as follow:

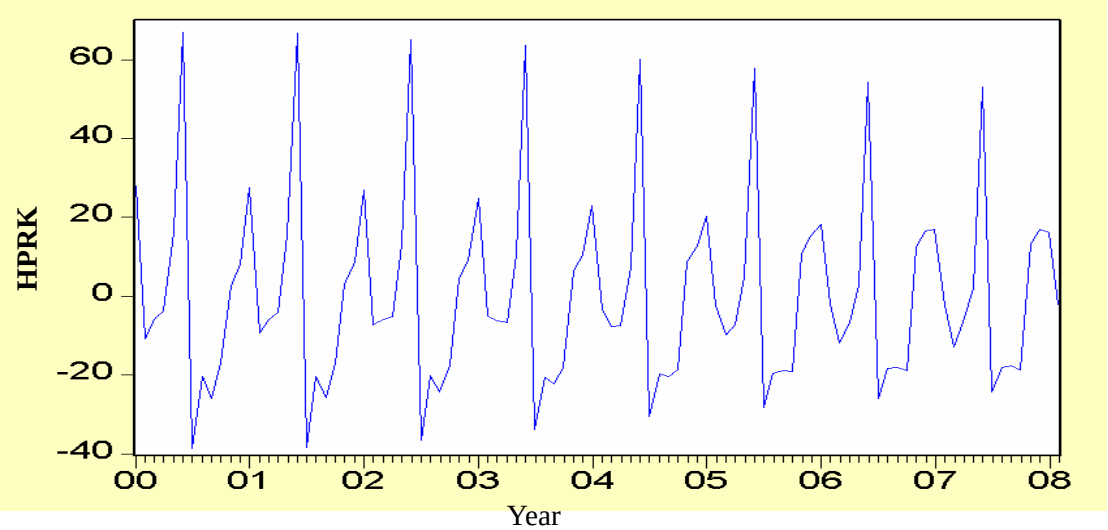

Figure 6: Seasonal factor series of the performance in the field Natural Science

According to the formulation:

$$\hat{w}_t = \hat{w}_t^* + \hat{w}'_t \qquad (4)$$

We can get the value of the $\hat{w}_t$. Figure 7 shows the linear graph of the forecasted data and the original data.

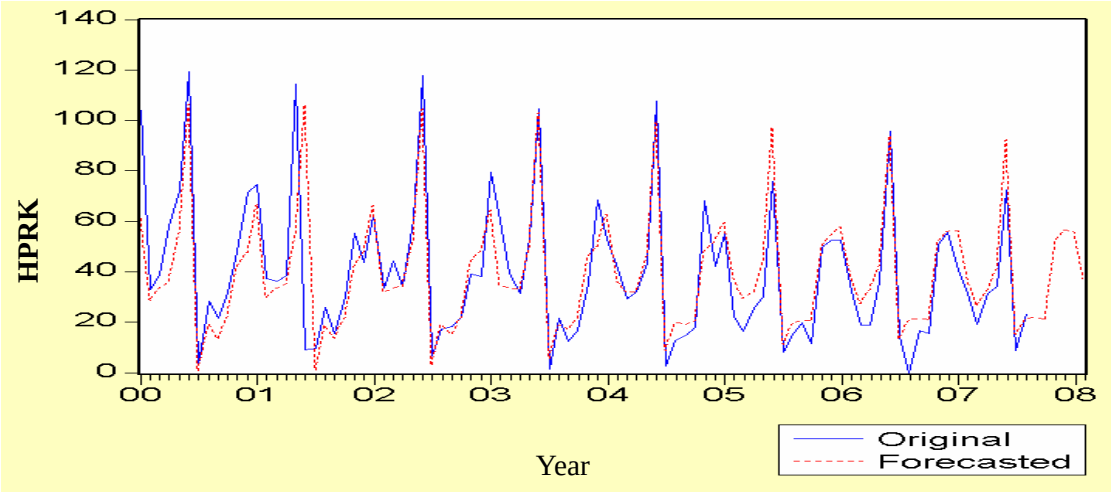

Figure 7: Comparison between the original value and the forecasted value of the performance in the field Natural Science

The mean absolute percentage error is 39.55 %. Then totally reimbursement of the field Natural Science can be calculated by the function:

$\hat{y}_t = c_1 * \hat{w}_t + c_2 * \hat{z}_t$ ($c_1 = 44\,706$, $c_2 = 37\,702$). Figure 8 shows the forecasted series of the reimbursement.

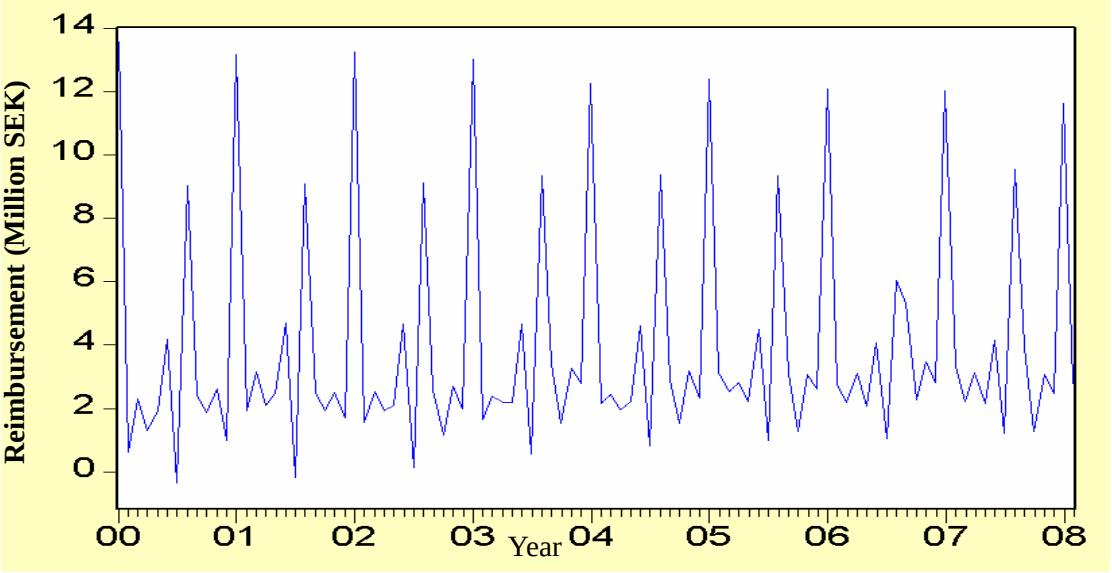

Figure 8: Forecasted series of the reimbursement in the field Natural Science

With the similar analysis for the other fields, we can get the total reimbursement of Dalarna University by summing the reimbursement of the 11 fields. The result has been shown in the next section. The analysis with the direct approach is quite similar as the indirect approach. We just model time series $\hat{y}_t$ directly. So we will show the comparison of the forecasted results in the next section. The analysis of the departments is also similar. Still the results will be shown in the section 5.

5. Comparison between the Census II Method and the ARMA Method

To compare which method is better on these two approaches and two levels, we choose the MAPE as an indication. Obviously the smaller the MAPE is, the better the model should be. To find out if there are some differences in short-term forecasting between the methods and the approaches on the two levels, we estimated three different forecasting lengths of 3 months, 6 months and 12 months. In order to make the results comparable, we give the predictions from Mar. 2007 to Feb. 2008. Take 3 months forecasting as an example; first we deem the data interval from Jan. 2000- Feb. 2007 as a set {A}. For the first 3month forecasting of Mar. 2007-May 2007, we use the set {A}. Then we use {A} + the original data of Mar. 2007-May

2007 to forecast the data of Jun. 2007-Aug. 2007. We use {A} + the original data of Mar. 2007-Aug. 2007 to forecast Sep. 2007-Nov. 2007. Finally, we forecast Dec. 2007-Feb. 2008 by the set {A} + the original data of Sep. 2007-Nov. 2007. After the steps above, we calculate the MAPE of the forecasted data from Mar. 2007-Feb. 2008. The results from Census II method are shown in the table below. We compare the results on the field level. Then we compare results on the department level in the similar way.

Table 4: Comparison in terms of MAPE between the direct and indirect approaches with the data classified by fields where the Census II is used for forecasting (%)

	Direct Approach			Indirect Approach		
Period / Field	3 months	6 months	12 months	3 months	6 months	12 months
Other	42.27	48.07	48.51	42.64	49.15	50.37
Humanity	32.41	33.54	35.94	32.89	37.28	38.73
Sport	92.39	104.27	109.51	116.41	130.40	143.03
Law	30.00	38.69	43.56	34.29	40.76	45.25
Education	27.44	34.43	37.52	27.37	35.89	37.92
Media	30.52	39.48	46.50	36.07	44.72	46.86
Medicine	21.38	22.54	24.94	22.93	23.19	25.68
Natural Science	27.98	32.38	35.49	33.54	37.38	39.94
Social Science	21.95	22.45	25.08	24.25	26.97	27.35
Technique	36.02	38.68	38.85	36.27	38.21	39.94
Health Care	27.81	31.23	34.35	27.95	34.36	34.49
Average MAPE	29.78	34.15	37.07	31.82	36.79	38.65

Because the Sport field is a quite small field and the data are too few to forecast, so we can ignore the effect it made. The Average MAPE is the average of all the fields except Sport.

Table 5: Comparison in terms of MAPE between the direct and indirect approaches with data classified by departments where the Census II is used for forecasting (%)

	Direct Approach			Indirect Approach		
Period / Department	3 months	6 months	12 months	3 months	6 months	12 months
Culture	30.60	35.87	36.51	32.60	37.32	39.94
Social	29.61	32.09	33.75	27.59	36.61	37.88
Health	27.15	32.97	35.65	29.54	33.54	37.68
Humanity	31.96	35.35	40.85	32.38	36.41	41.77
Industry	29.05	33.35	35.92	31.18	36.84	38.39
Average MAPE	29.67	33.93	36.54	30.66	36.14	39.13

From Table 4 and Table 5, on the average level, we can conclude the direct approach is better than the indirect approach. While the data classified by departments do some help to get a more accurate prediction than the data classified by fields. As mentioned above, in this thesis, we also tried the ARMA model. The results are shown in tables 6 and 7:

Table 6: Comparison in terms of MAPE between the direct and indirect approaches with data classified by fields where the ARMA is used for forecasting (%)

	Direct Approach			Indirect Approach		
Period / Fields	3 months	6 months	12months	3 months	6 months	12 months
Other	38.62	44..53	46.76	41.12	45.76	49.96
Humanity	25.45	28.96	34.92	27.31	30.11	35.36
Sport	57.06	66.37	70.83	57.50	69.59	72.09
Law	32.30	41.45	44.16	36.06	41.64	45.15
Education	25.82	30.63	31.85	27.23	31.85	32.75
Media	34.04	41.36	45.59	37.04	44.19	45.33
Medicine	27.55	29.97	35.99	27.38	31.09	34.25
Natural Science	24.80	35.17	35.41	25.68	30.92	35.77
Social Science	22.10	27.27	28.52	22.99	28.51	29.44
Technique	26.38	30.68	33.88	27.47	31.62	34.84
Health Care	21.09	27.89	28.96	22.47	27.94	29.57
Average MAPE	27.82	32.60	36.60	29.48	34.36	37.24

Table 7: Comparison in terms of MAPE between the direct and indirect approaches with data classified by departments where the ARMA is used for forecasting (%)

	Direct Approach			Indirect Approach		
Period / Department	3 months	6 months	12 months	3 months	6 months	12 months
Culture	25.49	34.24	36.45	24.24	34.87	35.23
Social	27.29	29.90	34.66	27.08	28.78	35.02
Health	27.51	31.23	35.01	25.16	30.17	35.72
Humanity	28.06	35.15	41.26	27.80	34.60	39.07
Industry	28.19	30.81	34.67	26.89	29.02	30.26
Average MAPE	27.31	32.27	36.41	26.23	31.49	35.06

Compared with the table 6 and table 7, again we get the conclusion that the forecasting result from the department level is better than the result from the field level. From the table 6, on average, the direct approach is also better than the indirect approach as mentioned in analysis of Census II. But it shows an opposite situation in table 7, the indirect approach achieves a better result. Compared with Census II method, the ARMA method seems to achieve a better result, no matter which approaches are applied to.

6. Conclusion

Judging from the rule that the smaller the MAPE is the better the forecasting result should be, we get the conclusion that on the average level, the indirect approach with the ARMA method and classify data on the department level achieves a better result. That is to say, to give a more accurate forecasting reimbursement of Dalarna University we had better try this path rather than the other paths. We analyze the reason why the ARMA model is better than the Census II method. As we have mentioned, Census II method puts emphasis on showing trend, season, circle and error. It decomposes the time series into these four components, but it is hard to give an accurate decomposition for the four parts. What's more, dealing with the data with the moving average method for too many times may lead to the reduction of the length of the time series. Compared with the Census II method, the ARMA method can make up these deficiencies. In addition, ARMA method pays more weights to the recent data, which means the forecasted result could be closer to the reality.

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Appendix

Appendix A: Example of Original data of HSTK in Natural Science Field

Period	observation	Period	observation	Period	observation
2000		2003		2006	
1	288.8844	37	255.41563	73	216.6725
2	19.825	38	18.49062	74	25.7425
3	63.7	39	26.33438	75	9.975
4	27.55	40	21.09999	76	41.975
5	28.95	41	4.125	77	13.975
6	22.7875	42	11.41251	78	6.375
7	1.4	43	2.15625	79	186.6656
8	197.45	44	168.65622	80	0
9	39.4375	45	57.1438	81	47.4038
10	39.4187	46	0	82	10.1544
11	78.9688	47	0	83	13.595
12	7.55	48	43.3225	84	0.635
2001			2004		2007
13	210.4812	49	229.17375	85	189.315
14	0	50	15.63755	86	32.7187
15	38.8626	51	51.4249	87	15.7313
16	14.475	52	10.8188	88	38.525
17	13.025	53	0	89	7.8025
18	27.6499	54	11.88	90	3.5
19	1.175	55	3.705	91	0.42407
20	196.3001	56	205.5031	92	153.44006
21	34.7749	57	36.1182	93	24.64502
22	48.1688	58	4.705	94	23.98663
23	39.45	59	26.6999	95	12.68166
24	7.1875	60	2.03	96	2.73499
2002		2005		2008	
25	246.2875	61	194.52	97	190.7245
26	19.3063	62	22.2312	98	25.24918
27	35.4374	63	20.0688		
28	25.5376	64	28.175		
29	4.7812	65	1.175		
30	20.7875	66	9.43		
31	8.2	67	6.425		
32	198.05	68	197.405		
33	68.6062	69	52.4487		
34	22.275	70	6.0751		
35	28.6501	71	14.1975		
36	7.3187	72	3.8849		

Appendix B: Example of Original data of HPRK in Natural Science Field

Period	observation	Period	observation	Period	observation
2000		2003		2006	
1	104.0406	37	79.54375	73	52.41625
2	33.00937	38	60.18745	74	32.3225
3	38.9031	39	39.43755	75	18.83875
4	58.0988	40	31.51125	76	18.6969
5	72.0194	41	53.0612	77	36.07873
6	119.2481	42	104.4782	78	95.72749
7	2.86875	43	1.40623	79	14.1875
8	28.24687	44	21.45937	80	0
9	21.50825	45	12.3625	81	16.60688
10	31.72865	46	16.7438	82	15.61125
11	47.9399	47	35.2412	83	50.81375
12	71.6524	48	68.5662	84	55.5775
2001		2004		2007	
13	74.52187	49	52.70875	85	40.69375
14	37.16873	50	41.07188	86	31.3275
15	36.3938	51	29.3675	87	19.035
16	38.34997	52	32.11625	88	31.46755
17	114.5139	53	43.29124	89	34.2912
18	9.0374	54	107.825	90	72.325
19	9.6903	55	2.4663	91	8.6517
20	25.909	56	12.7625	92	23.3783
21	15.5581	57	14.7906	93	10.6825
22	30.1125	58	17.77	94	12.2567
23	55.2988	59	68.30375	95	36.8008
24	74.52187	60	42.25375	96	45.2725
2002		2003		2008	
25	43.6511	61	54.91875	97	53.09418
26	62.3115	62	22.25125	98	22.44625
27	33.4825	63	16.475		
28	44.3813	64	25.54375		
29	34.0987	65	30.24685		
30	60.8406	66	75.6825		
31	117.8094	67	8.025		
32	6.4625	68	15.2913		
33	17.4375	69	19.81		
34	18.0813	70	11.4937		
35	22.0781	71	49.8388		
36	38.9832	72	52.4087		

Appendix C: Different Reimbursement Level for Different Science Field

Table A (HSTK) – registration (SEK)

Field		Amount
Humanity	HU	19 465
Sport	ID	89 681
Law	JU	19 465
Education	LU	29 719
Medicine	MD	50 875
Media	ME	260 810
Natural Science	NA	44 706
Social Science	SA	19 465
Technique	TE	44 706
Health Care	VÅ	45 527
Other	ÖV	35 903

Table B: (HPRK) - performance (SEK)

Field		Amount
Humanity	HU	17 085
Sport	ID	42 895
Law	JU	17 085
Education	LU	35 385
Medicine	MD	63 924
Media	ME	211 087
Natural Science	NA	37 702
Social Science	SA	17 085
Technique	TE	37 702
Health Care	VÅ	40 299
Other	ÖV	29 165