American Journal of Educational Research, 2015, Vol. 3, No. 8, 1015-1019
Available online at http://pubs.sciepub.com/education/3/8/11

DOI:10.12691/education-3-8-11

The Time Equations and Formula Budgeting in Jointed Model for Higher Education

Cheporov Valeriy, Cheporova Galina*

Economic Faculty, V.I. Vernadsky Crimean Federal University, Simferopol, Republic of Crimea, Ukraine
*Corresponding author: cheporov@crimea.edu

Received June 28, 2015; Revised July 15, 2015; Accepted July 23, 2015

Abstract Formula budgeting is the most common and simple method of university funding, which is based on the amount of funding for all the resources or just FTE staff, depending on the number of students. The aim is to establish the relationship between demand and supply of resources as a function of the number of students and levels of activity. The paper develops a model of non-monetary break-even in the meters by combining both time equations of time driven activity based costing and formula budgeting. Results for Ukrainian universities show that the tuition fees provide less means of student / teacher ratio, than the one proposed by the Government.

Keywords: *time equations, formula budgeting, jointed model, higher education*

Cite This Article: Cheporov Valeriy, and Cheporova Galina, "The Time Equations and Formula Budgeting in Jointed Model for Higher Education." *American Journal of Educational Research*, vol. 3, no. 1 (2015): 1015-1019. doi: 10.12691/education-3-8-11.

1. Introduction

Unlike the private sector where the price should provide funding for all resources in the production of products or provision of services in the public sector each resource may be financed in a separate process that can generate excess or deficiency of some resources at their joint consumption. Generally, the rate of resource utilization is measured by ratio of actual use of capacity to the normative.

We propose to consider the difference between these tanks, which means an excess or deficiency between the proposed and consumption capacity. This difference is an indication of just compensation by the government cost of the university.

2. Literature Review

In 1996, Steven Anderson founded Acorn Systems, Inc., to focus on medium-sized enterprises. "He saw how ERP systems enabled him to work directly and naturally at the transaction level to measure the drivers of process time consumption. He developed time equations to describe how different types of orders or transactions consumed process time in departments"(Kaplan; Anderson (2007) [6], p. x.). Kaplan joined to Acorn's board of directors in 2001 and began to collaborate with Anderson and the Acorn team on how to make their approach even more powerful. These discussions led to an integration of the capacity-costing approach that Robert Kaplan and Robin Cooper had advocated in Cost & Effect with Anderson's time algorithms for modeling transaction complexity.

Kaplan and Anderson described the integrated TDABC approach in a November 2004 Harvard Business Review article (Kaplan; Anderson (2007) [6], p. xi.). This work was preceded by the working papers in draft form by R. Kaplan and S. Anderson (Kaplan; Anderson (2003) [7]), in which the time-driven approach estimates the resource demand by a simple equation for packaging time.

Time equations greatly simplify the estimation process and produce a far more accurate cost model than would be possible using traditional ABC techniques. Developing appropriate time equations is essential part of TDABC since it will affect how close we can estimate the required time.

Time equation for a given activity is function of n potential factors differentiating this activity, which is expressed in following way (Kaplan and Anderson, 2007 [6], p. 31)

$$T = \beta_0 + \beta_1 X_1 + ... + \beta_n X_n$$

where:
T - time needed to perform an activity,
β_0 - standard time for performing the basic activity,
β_i - estimated time for the incremental activity i, $i = 1, ...n$,
X_i - quantity of incremental activity i, $i = 1, ...n$.

The use of funding formulas to calculate the amount of public funding allocated to universities, is widespread in Europe. However, the degree of importance of the formulas, along with other mechanisms of allocation of public funding varies from country to country (Eurydice, 2008) [5].

For the purpose of our work is to understand the important point to the fact that throughout the world the funding formula similar and fit into the typology proposed by Francis Gross in 1979 (Gross, 1979 [4]). A useful overview of early work presented Richard Fonte (Fonte, 1987).

Ken Snowdon (Snowdon, 2011 [9]) presented the modern results of a comparative analysis of funding formulas in the United States and Canada. His data are relative and normalized to the number of students to one established teachers' post related to the mother tongue.

It should be noted that the relative amount of funding in the US and Canada for higher medical and engineering graduates than in Ukraine, but lower for professions related to art.

3. Methodology and Results

3.1. Time Equations in Higher Education as Resource Demand

Usually total paid hours for academic staff in Higher Education based on: teaching activity, research activity, and administration / management activity. Distribution of the common time recourses of university teachers by type of activity can be carried out as follows (Bruggeman, 2010 [1]):

Teaching: Used capacity calculated by time equations;

Administration and management: Discretionary reserved capacity based on standard percentage times;

Research: Residual capacity.

Let's consider time equations in higher education for teaching activity. For example, W. Bruggeman (Bruggeman, 2010 [1]) proposed time equation for cost of teaching of an undergraduate course taught by a senior professor.

$$\begin{aligned}&\text{Time} = \text{time to prepare course material}\\&+\text{lecture and preparation time}\\&+\text{time for reading and marking assignments}\\&+\text{preparing examintion papers} + \text{preparing and marking}\\&\text{examination papers } + \text{time for conducting oral exams}\\&+\text{special care of foreign student}\end{aligned}$$

or

$$\begin{aligned}&\text{Time} = 5\text{hrs} + 3\text{hrs(number of contact hours)}\\&+1\text{hrs(number of contact hours, if tea-cher is junior)}\\&+0.5\text{hrs(number of students)} + 3\text{hrs}\\&+0.5\text{hrs(number of students)} + 25\text{hrs(number oral exams)}\\&+1\text{hrs(the number of foreign students attending the course)}\end{aligned}$$

Result with 30 contact hours, 300 students, no oral exams, 10 foreign students is

$$\begin{aligned}Time &= 5 + 3\cdot(30) + 1\cdot(0) + 0.5\cdot(300) + 3\\&+ 0.5\cdot(300) + 25\cdot(0) + 1\cdot(10) = 408hrs\end{aligned}$$

If the total salary cost of academics in the department is €560 000, the estimate practical capacity of the academic staff is 8000 hours, then the cost / hour is €70/hour, the cost of the course is 28560€ (408 hours x 70€), the cost per student is 95,2€ (28560/300).

We offered to form time equations curriculum / program rather than by department (Cheporov and others, 2004 [2], in English).

Any educational program consists of the individual disciplines (modules). Each module is measured in a certain number of hours. These hours must be covered to provide resources. Some of these hours are called teaching workload and they are associated with the direct contact of students and teachers. Therefore, the teaching staff is an essential resource for the realization of educational activity.

Contact workload is implemented in various ways, most often one teacher for a different number of students simultaneously. The number of hours of training workload can be written in mathematical form.

Let s_y is the number of students enrolled in the y-year of any program; A_{jy} is number of units of students associations, j is a level of teaching workload, for example, the number of students, groups, lectures and other streams on the program.

We assume that A_{jy} is ordered as the number of students in a variety of associations of students and covers all variants of associations; hc_{ijy} –is the number of contact hours of training; I and J + 1 is respectively the number of subjects (modules) and units associations of students in the program. Then, for example, $A_{0y}= s_y$ и $A_{Jy}= 1$.

Contact workload for all students of the program, adopted in a particular year of study, with an equal number of students in their unions for all years of schooling can be expressed as the following expression.

$$Hc_{progr} = \sum_{y=1}^{Y}\sum_{j=0}^{J} A_{jy}\sum_{i=1}^{I} hc_{ijy} = s \times Vhs + \sum_{j=1}^{J} A_j \times hc_j \quad (1)$$

where:

s - is the same number of students in the program in each year of study;

$Vhs = \sum_{y=1}^{Y}\sum_{i=1}^{I} hc_{i0y}$ - is academic load on the program for the entire period of training per individual student;

$hc_j = \sum_{y=1}^{Y}\sum_{i=1}^{I} hc_{ijy}$ - is academic workload on the program for the entire period of study for students j- level association (in the hierarchy).

At steady number of students the expression (1) reflects the total annual workload for all students in this program, i.e.

$$Hc_{programm} = Hc_{academic\_year}$$

Note that each student in the program must obtain on average

$$Hc_{student} = \sum_{y=1}^{Y}\sum_{j=0}^{J}\sum_{i=1}^{I} hc_{ijy}$$

contact hours.

However, some students may use fewer contact hours compared with the others, especially in individual work. It is important that each teacher has fulfilled its workload and is reflected in a report on the efforts.

In Ukraine the activity level of a student includes oral examinations, advice on training individual work of students, term papers etc. Activity at the level of the group includes classroom training in a group, tests, advice on subject matters, management practices. At the level of the course activities include lectures and individual consultations.

I.e.

$$\begin{aligned}\mathrm{hc}_{\mathrm{student}} &= 0{,}33\cdot(\text{number of oral exams})\\&+(\text{from 2 to 4})\cdot(\text{number of term papers})\\&+(\text{from 0,25 to 0,5})\\&\cdot(\text{number checked student course papers})\\&+\text{if(there is thesis, 25hrs for thesis}\cdot\text{consulting,0)}\\&+2{,}5\cdot(\text{number of state exams})\end{aligned}$$

$$\begin{aligned}\mathrm{hc}_{\mathrm{group}} &= 2\cdot(\text{number of seminars})\\&+2\cdot(\text{number of pass/fail exams})\\&+3\cdot(\text{number of writing exams})\\&+(\text{6\% from total hours per subiect})\\&\cdot(\text{number of subjects})\end{aligned}$$

$$\begin{aligned}\mathrm{hc}_{\mathrm{all\_groups}} &= 2\cdot(\text{number of lectures})\\&+(\text{to 10\% from total hours per subiect})\\&\cdot(\text{number of subjects for individual consulting for studets})\end{aligned}$$

3.2. Formula Budgeting as Resource Supply

In most countries, the financing teachers' salaries in public universities are realized in proportion to the number of students. In Ukraine, the ratio of full-time students to the number of teachers at the level of bachelor's degree varies from 5: 1 for directions "physical rehabilitation", "architecture" and "art" to 13.5: 1 for the direction of "tourism". This ratio for engineering graduates is set to 9.5 to 11.5 to 1, and for medical specialties is 8: 1. For part-time students these figures are increased by 4 times.

Established link between the number of students and teachers denote will be

$$Kst = \frac{Student}{Teacher} \tag{2}$$

Let's consider that the financing of other costs does not affect the rate. Then (1) with (2) can be written as

$$\frac{Kht_{\max}}{Kst}\cdot Y\cdot s \ge s\times Vhs + \sum_{j=1}^{J} A_j \times hc_j \tag{3}$$

where:

$Kht_{\max}$ - is the maximum teaching workload per FTE teacher staff;

T – is the number of FTE teachers' staff.

Inequality (3) is an analog of the inequality in the model of marginal analysis in training hours, which $\frac{Kht_{\max}}{Kst}\cdot Y$ is an analogue of the price, Vhs- analog of variable costs per unit, $\sum_{j=1}^{J} A_j \times hc_j$ - analogue semi-fixed costs.

Note that in Ukraine the left side of inequality (3) for part-time students takes a smaller value compared with full-time day students, as Kst increased 4 times, and T is increased by only 20%. The right-hand side of inequality (3) also assumes a smaller value due to the smaller number of lectures and seminars. For part-time students a time contribution margin to cover fixed hours takes a smaller value. This can lead to a situation where the resources for full-time students are used for part-time students. Legally, it is not always allowed

Let's consider the case of tuition fees. The necessary conditions coverage staff salaries by income students can be written as:

$$\mathrm{r_y} \times \mathrm{s} \times Y \ge \mathrm{T} \times \mathrm{c_y} \tag{4}$$

where:

$\mathrm{r_y}$ is a annual payment by students;

$\mathrm{c_y}$ is an annual rate of remuneration for teachers.

In Russia and Ukraine, the public university forms first contingent of students from the government budget, and then - at their own expense students.

Therefore, the budget proposed to the students according to the number of rates according to students $\mathrm{s_G}$, which education is funded by the government (2), and the number of additional rate determined from inequality (4) $(s-\mathrm{s_G})$ of tuition fees students. Therefore, you can get the following the necessary conditions:

$$\begin{aligned}&Kht_{\max}\cdot Y\cdot\left(\frac{\mathrm{s_G}}{Kst}+\frac{\mathrm{r_y}}{\mathrm{c_y}}\cdot(s-\mathrm{s_G})\right)\\&\ge s\times Vhs+\sum_{j=1}^{J} A_j\times hc_j\end{aligned} \tag{5}$$

Inequality (4) is stronger than the inequality (3), as the annual fee the student must cover the rate of teachers to ensure that meet the demand for resources.

It is worth noting two points. Firstly, increasing the number of students changes the meaning of A_j, and secondly, the ratio $\frac{\mathrm{r_y}}{\mathrm{c_y}}$ is not constant, decreasing function of the number of students that is more consistent with a competitive market, i.e.

$$\frac{\mathrm{r_y}}{\mathrm{c_y}} = F - E\cdot(s-\mathrm{s_G}) \tag{6}$$

where:

F, E - the market variables.

At the point $\mathrm{s_0}$ (Figure 1) the demand for resources is equal supply at maximum workload rate FTE teacher. From the point $\mathrm{s_0}$ to the point $\mathrm{s_G}$ resource supply increases in proportion to the number of students.

To the right of the point $\mathrm{s_G}$ resource supply may vary depending on the market structure. The straight line corresponds to perfect market, but a curve - a monopoly market.

For a monopoly market there is a point in which residual income is maximized.

Note that the axis H (workload hours) can be replaced axis T (FTE staff members), which is more understandable for decision-making.

That is, the inequality (5) can be written as

$$\frac{s_G}{Kst}+\frac{r_y}{c_y}\cdot(s-s_G)\geq\frac{1}{Kht_{max}\cdot Y}(s\times Vhs+\sum_{j=1}^{J}A_j\times hc_j) \quad (7)$$

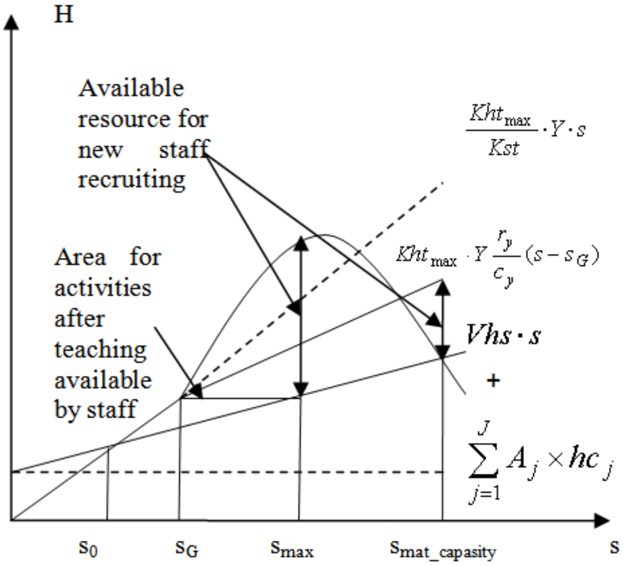

Figure 1. Resource Supply-Demand Model for Formula Budgeting and Time Equations

3.3. Target Function

Despite government funding, state university wants to increase its revenue by the personal money of students. Such funding may cover not only the salaries of teachers, but also to provide net income, which can be used for other purposes.

Inequality (5) can be regarded as an target function to guide the University to maximize the remaining resources.

$$\text{Residual capacity}=Kht_{max}\cdot Y\cdot(\frac{s_G}{Kst}+\frac{r_y}{c_y}\cdot(s-s_G)) \quad (8)$$
$$-s\cdot Vhs+\sum_{j=1}^{J}A_j\cdot hc_j\to\max$$

The target function (8) can be written for each of the educational program or for aggregated portfolio programs. However, the strategy of maximizing income can meet the problem of special skills of teachers. This situation can lead to staff turnover or retraining, as happened in the 90 years with the growth in demand for economic education.

A more reasonable strategy is to increase income by changing the personal workload of teachers in a relevant range, or the introduction of elective courses the relationship for the case of point

The optimal solution for the target function (8) depends on the monopoly market variables (E, F), parameters of the time equation for a student, the number of students financed by the government and regulatory funding formula. Figure 2 shows for case $F-K_c>0$ dependence of points x_{max} from $z=\frac{\Delta T_G}{K_c}$.

where

$x_{max}=s_{max}-s_G$

$\Delta T_G=K_n\times s_G-K_c\times s_G-b$

$$K_n=\frac{Y}{Kst_n},K_c=\frac{Vhs}{Kht_{max}},b=\frac{1}{Kht_{max}}\sum_{j=1}^{J}A_j\times hc_j$$

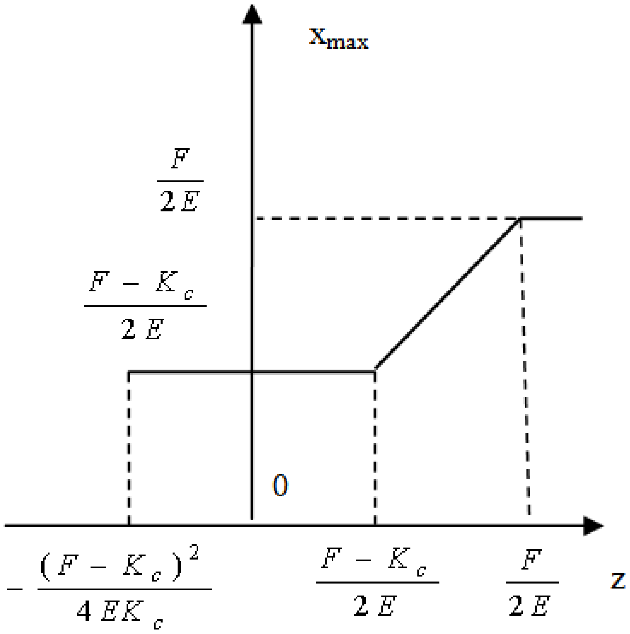

Figure 2. Schedule optimal points

The value $x_{max}=s_{max}-s_G$ will have the form

$$x_{max}=\begin{cases}\frac{F-K_c}{2E},-\frac{(F-K_c)^2}{4EK_c}<z<\frac{F-K_c}{2E}\\ z,\frac{F-K_c}{2E}<z<\frac{F}{2E}\\ \frac{F}{2E},z>\frac{F}{2E}\end{cases} \quad (9)$$

If $F-K_c<0$, then the value $x_{max}=s_{max}-s_G$ will have the form

$$x_{max}=\begin{cases}z,0<z<\frac{F}{2E}\\ \frac{F}{2E},z>\frac{F}{2E}\end{cases} \quad (10)$$

The target function (8) is necessary to add restrictions on material resources (space). The minimum requirement of material resources per unit time is determined by the conditions.

$$A_j\cdot hc_j\leq\sum_{k=j}^{J}Hry_k,\forall j,j=0,J \quad (11)$$

where:

Hry_j - annual capacity of j recourse.

Thus deficit resource with less capacity can be compensated by excessive resource with a higher capacity per time unit.

Table 1 shows the evaluation of Residual capacity for FTE staff (residual income) for one of Ukrainian universities.

Results for Ukrainian universities show that tuition fees provides less important student / teacher ratio, than the one proposed by the Government.

Table 1. Actual Data of a Ukrainian University on Available FTE Staff Supply for FTE Students for a Current Year

	2005	2006	2007	2008	2009	2010	2011	2012
The number of students recruiting for payment	924	746	638	549	471	593	293	735
The weighted average number of students to fund a FTE staff member	4.2	4.1	4.4	4.7	3.9	4.9	5.6	6.8
The weighted average number of students to fund a FTE faculty member*				6.6	5.5	5.5	5.8	6.5
The number of FTE faculty members at the standard students/ teacher ratio	81.5	65.7	56.3	48.1	41.6	55.0	27.1	67.9
Residual capacity for FTE staff (residual income)	137.8	116.2	87.6	69.1	80.3	67.1	25.5	39.9

*for four years baccalaureate at a fixed student payment rate and staff salary growth.

4. Conclusions

On practice, the Department of the university or a private instructor (staff member) carries out teaching activities for a number of levels and courses of study. Expenses of departments can be measured in money or quantity of the resource (rates). Therefore, the first step in an amount of resources department rates should be distributed among individual programs on the basis of driver activity (time). By combining the resources of all the units in each program you can get a temporary equation for each program. You can use the other way - the construction of a temporary equation based on the curriculum and set quantitative parameters of hierarchy levels of students. In case of formula funding the demand for resources, based on the time equation, it should be covered by the supply of resources, based on the number of students to the number of teachers and the maximum teaching load on one bet. In turn, the market has a significant impact on the amount of money supplied and consequently the possibility of an additional set of teachers.

This approach can be built inequalities in educational hours, like in the classical inequality CVP analysis.

References

[1] Bruggeman, W., "*Full Economic Costing using Time-Driven Activity Based Costing*". B&M Consulting, 2010. Available: http://www.eua.be/Libraries/Country_Workshop_Belgium_2011/Werner_Bruggeman_-_Full_Economic_Costing_using_Time-Driven_Activity_Based_Costing.sflb.ashx. [Accessed Nov. 15, 2011].

[2] Cheporov, V. and Cheporova, G., "The CVP-model for the contact workload in university" in *3 International Seminar on the Quality Management in Higher Education*", Casa de Editura, 333-338.

[3] Fonte, R.W., "Community College Formula Funding: A Policy Analysis Framework", *Community College Review*, 15(2), 5-13. 1987.

[4] Gross, F.M., "*Formula Budgeting and the Financing of Public Higher Education: Panacea or Nemesis for the 1980s?"*, AIR Professional File, 3, 1979.

[5] "Higher Education Governance in Europe. Policies, structures, funding and academic staff" (2008) Available: http://eacea.ec.europa.eu/education/eurydice/documents/thematic_reports/091EN.pdf. [Accessed Nov. 15, 2011].

[6] Kaplan, R. S. and Anderson, S. R., *Time-driven activity-based costing: a simpler and more powerful path to higher profits*, Harvard Business School Press, Boston, 2007.

[7] Kaplan, R. S. and Anderson, S. R., "*Time-Driven Activity-Based Costing"*. [Working paper]. #04-045, 2003. Available: http://www.hbs.edu/research/facpubs/workingpapers/papers2/0304/04-045.pdf. [Accessed Nov. 15, 2011].

[8] Kaplan, R. S. and Anderson, S. R. "Time-Driven Activity Based Costing," *Harvard Business Review*, 82(11), 131-138, 2004.

[9] Snowdon, K., "*Higher Education Costs and Cost Drivers Looking forward – by revisiting the past."* A Review of Cost Studies, Formula Funding and Cost Drivers. [Working Draft]. November 2011. Available: http://www.snowdonandassociates.ca/Costs%20and%20Cost%20Studies.doc. [Accessed Jan. 28, 2013].