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Wages, Productivity and Optimal Payment in Efficient Software Projects

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ABSTRACT
In this paper we will study theefficiency wages, productivity, optimal payment and employment. Managerial Economics theory about these topics will be put in practice by research done on the Software Development Department of a software company. Having several samples of input cost and output productivity over the last years this data will help us into demonstrating how theory is put in practice. The paper present the optimal software team structure based on the experience levels of its members and the cost per each level. Simulations are performed with different members that demonstrate the best combination of seniority levels versus the total company cost per member.
Keywords: Cost, Efficiency, Optimal Payment, Productivity, Software Projects, Wages.

I. INTRODUCTION

A Software Development Department is providing internal support and development services for all departments within the company. The department is running in a totally independent mode by not sharing anything with any other department. Hence its cost and productivity is measurable exactly as if would have been a third party company. Due to this fact, benchmarking vs. other companies in the market offering similar services is performed. The department's data regarding cost and output is gathered from the last three years, varying from 20 Full Time Employees (FTE) to 30 FTE, while all cost data about wages, utilities, office like Total Company Cost per FTE, abbreviated further as TCC/FTE are fully available and sampled over the years. The output is considered to be the hour of development service provided. This 'hour' is the unit of measure for many Software Development Companies, as "invoice-able hour'.

The paper will also cover the topic of efficiency wages, which states, among other fact, that the higher wages vs. market average the higher the productivity and lower people turnover.

Tables with sampling data along with relevant chart will be provided as well to depict visually the findings. Using the information from all the tables with data a "what if scenario" is made specifically that provides the optimal level of employment to achieve a specified target.

II. BACKGROUND AND STUDIES REVIEW

The background in this paper is chapter *Production and Competitive Markets* from the text book [1]. The managerial application 7-1, about efficiency wages discusses the topic in detail with regards to the fact that supply and demand is not the only factor that sets the wages. In [1] is presented the theory that "*The efficiency wages hypothesis argues that wages and employment levels are sometimes determined by more than the simple interplay of supply and demand. At times, there may be incentives for managers to pay employee "efficiency wages" that might be more than the marker-clearing wage rate*". The efficiency wages are considered to be incentives for the employees hence they will be performing better by having given these higher wages. The fact an employer is known as offering efficiency wages attracts more capable workers. According to studies [9-11] and companies financials data it seems for them that the efficiency wages takes effect, as these companies have grown bigger and bigger, their revenues and profits increases over the year. The correlation between the efficiency wages and productivity, which further translated to revenues and profits, is true for them.

III. THE WORK CONTEXT IN A SOFTWARE COMPANY

The paper presents the software development department of a healthcare company. The software department operates totally separated than other departments within company, having its own budget,

cost, offices, and employees. Giving this cost and output it is monitored very accurately and computation are being able to be performed. The input used by the department is a single input, being labor, FTE or X. The cost of input X can vary according to seniority / experience of the FTE. The average TCC of FTE in the last three years varies from 3000 EUR/month to 3200 EUR/month. There are three levels of FTE identified by their seniority / experience: seniors (SEN), mediums (MED), and juniors (JUN).

These inputs have different cost and different level of output. They will be abbreviated further as SEN, MED and JUN. The output is "invoice-able hour" abbreviated as "h", known in theory as output product and quantity. The ideal maximum theoretical output for and input X is 140 hours / month. The historical data about productivity, quantity and quality is gathered in the internal KPI web site. Several screen shoots of the KPI internal web sited are provided in Figure 2. The cost of input for every year, drilled down for each levels SEN, MED, JUN are taken from the financial system, while the number of attritions / people turnover are taken from the HR system. Thus, we are having all the necessary data to perform the required computations and further analysis.

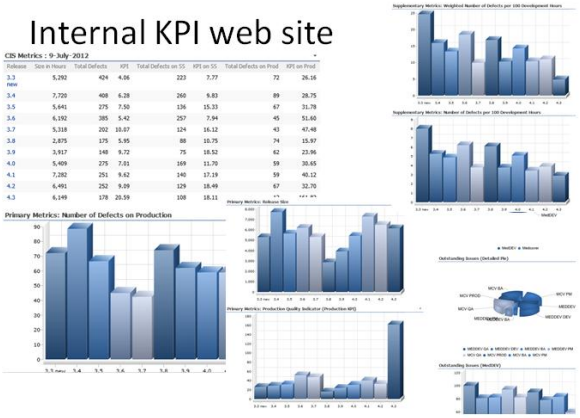

Figure 1. The platform for computing KPI indicators

As presented in Figure 1, the analyzed software company has already in place an internal mechanism of computing the performance indicators. The formula used for computing these indicators is not presented in this paper, it is only highlighted that such a system must exist in order to be able to measure and validate the proposed approaches.

IV. TOTAL PRODUCT, RETURN TO SCALE

The costs of input and total product are displayed in Figure 3. We notice that the more absolute input X the more absolute total product we get. The isoquants are not being used and cannot be used as we have single input, namely labor. In order to have a relevant comparison, the quality of output is also weighted. As it is noticed in Table 1, as more FTE is added in subsequent years the more it is obtained. Taking into account the quality for each of these years we notice that the ratio of cost/unit/quality decreases every year, which is a good direction for a trend. Figure 2 depicts how the total product increased as we added more input.

Table 1. Inputs, Cost in EUR, Output and Quality over 2010, 2011, 2012

Input Cost/Output/Quality			
	2010	**2011**	**2012**
Number of FTE	15	19	23
Total Cost per year	570000	670000	840000
Cost / FTE	3200	3000	3100
Output (in hours)	15900	19500	26000
Cost / unit of output	35.8	34.4	32.3
Quality (KPI)	7.2	8.3	9.5
Cost / KPI	4.98	4.14	3.40

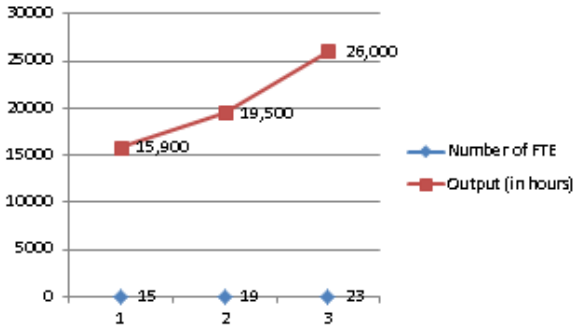

Figure 2. Total Product increases as we add more input (15FTE, 19FTE, 23FTE)

Marginal product is computed as depicted in Table 2. As we notice, when input was increased from 15 FTE to 19 FTE the average product decreases in comparison with its initial value, while adding 4 more FTE the average product increases. At the first increase in input we faced a decrease return on scale (DRC) then after the second input increase we faced an Increasing Return on Scale (IRS). Marginal Product increase after each subsequent input is displayed in Figure 3.

Table 2. Marginal Product and Average Product for 3 inputs (15FTE, 19FTE, 23FTE)

Unit of labor employed (FTE)	**Total Product-hours per year (TP = Q)**	**Marginal Product (MP = dQ)**	**Average Product (AP = Q/X)**
15	15900	15900	1060
19	19500	3600	1026
23	26000	6500	1130

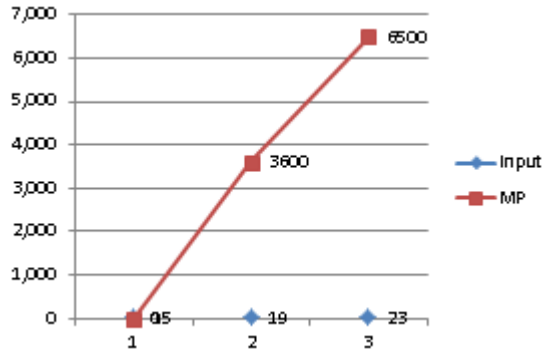

Figure 3. Marginal Product vs. each input increase (15FTE, 19FTE, 23FTE)

Computation about point output elasticity is depicted in Table 3.

Table 3. Point Output Elasticity

Input (FTE)	Output (hours)	Percentage Change in Input	Percentage Change in Output	eQ	Return to Scale
15	15900	0.00	0.00	1	
19	19500	26.67	22.64	0.85	**Decreasing**
23	26000	21.05	33.33	1.58	**Increasing**

The point elasticity is measuring what percentage change in output is obtained in case a percentage change in input occurs. It is observed that once a DRC it is followed by an IRS. A company should always increase the input as long there is IRS. A CRS will be then reached while a company needs to balance whether or not it should add more and more input even though it enters in the DRS zone. For the studied software department it seems more input can be added as the IRS zone is not effective. Due to insufficient sampling data it is difficult to assess when the CRS and DRS will be reached.

V. EFFICIENCY WAGES

In [3] is stated that "Economic theory says that the wage a worker earns, measured in units of output, equals the amount of output the worker can produce. Otherwise, competitive firms would have an incentive to alter the number of workers they hire, and these adjustments would bring wages and productivity in line".

Recent researches [2, 6-8] as well as old papers [12] show that a topic of current analysis in productivity growth must answer the question: is salary or not a factor that can lead to increased productivity with its growth? When a company pays above the market average salary for a position established by it, is called efficiency wages, but also the main reason this happens is that the company expects the additional payment to increase employee productivity, it is much more motivated than an employee who is earning the average salary of the company. At the same time, wage growth combined with stagnant productivity increase costs for different reasons and in most cases increase prices, assuming that profit is intended to remain constant. So if wages versus productivity growth is in the following situations, the following reactions appear:

i. Elastic - meaning that with wage growth and productivity increases in an exponential pace, at that time if market demand is the same, productivity growth may lead to reduced prices;
ii. Elasticity is directly proportional to production, in that time prices will stagnate if demand is high so that it can be satisfied at the same sale price;
iii. Inelastic - when wage growth (or cost) not directly increase productivity in a situation where in most cases prices will increase.

To calculate productivity in comparison to wage by assessing the average wage versus average productivity the theory described in [3] is analyzed which states that *According to theory, the right measure of productivity for determining real wages is the marginal product of labor - the amount of output an incremental worker would produce, holding constant the amount of capital*.

A real case example is provided in the next paragraphs. There are three levels of wages SEN, MED, JUN. Each of these levels of inputs has different costs and different productivity as well. The ratio between wage and productivity is computed for each of these three levels. Regardless the cost, the productivity is different for each of these levels, productivity for JUN is 0.72, productivity for MED is 0.81 and productivity for SEN is 0.83 as computed in Table 4. These values represent the percentage from worked time translated into real output (invoice-able hour). Taking the productivity factors in account, we obtain a relevant cost for unit of output for each of the three levels, as follows: JUN = 13.8 EUR/h is the best one, followed by the MED = 20.7 EUR/h, the last one being SEN = 26.8 EUR/h as shown in Table 4.

Table 4. Productivity versus wages

5.5 Months Overview (January to mid June 2012)							
Experience Level	**Actual Output (hours)**	**Ideal Maximum Output**	**Percentage Actual vs. Ideal (Productivity Factor)**	**TCC (EUR)**	**Actual TCC/Output**	**Ideal TCC/Output**	**Delta EUR (Ideal – Actual)**
SEN 1	720	770	0.94	15400	21.4	20.0	-1.4
SEN 2	615	770	0.80	18700	30.4	24.3	-6.1
SEN 3	496	770	0.64	17050	34.4	22.1	-12.2
SEN 4	738	770	0.96	17600	23.8	22.9	-1.0
SEN Avg.	**2569**	**3080**	**0.83**	**68750**	**26.8**	**22.3**	**-4.4**
MED 1	351	770	0.46	11550	32.9	15.0	-17.9
MED 2	631	770	0.82	12650	20.0	16.4	-3.6
MED 3	460	770	0.60	14850	32.3	19.3	-13.0
MED 4	859	770	1.12	10450	12.2	13.6	1.4
MED 5	827	770	1.07	15400	18.6	20.0	1.4
MED Avg.	**3128**	**3850**	**0.81**	**64900**	**20.7**	**16.9**	**-3.9**
JUN 1	1044	770	1.36	9350	9.0	12.1	3.2
JUN 2	552	770	0.72	9350	16.9	12.1	-4.8
JUN 3	259	770	0.34	5500	21.2	7.1	-14.1
JUN 4	369	770	0.48	6600	17.9	8.6	-9.3
JUN Avg.	**2224**	**3080**	**0.72**	**30800**	**13.8**	**10.0**	**-3.8**

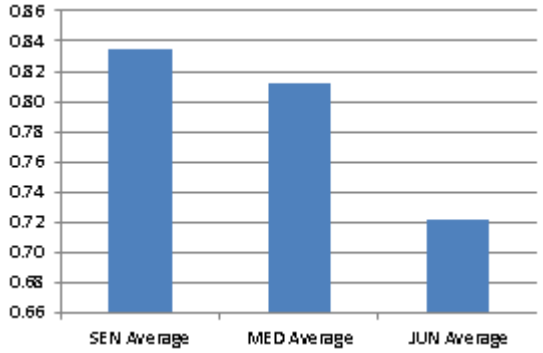

Figure 4. Productivity factor, percentage throughput, versus levels of seniority

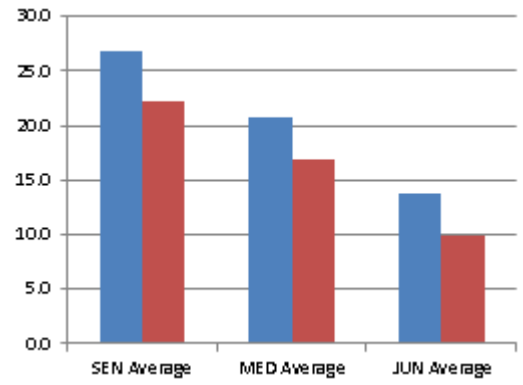

Figure 5. Cost per output unit versus levels of seniority (blue = actual, red = ideal).

According to the studied case, it seems paying efficiency wages to MED and SEN does not provide better productivity, when we come to divide cost versus output, as seen in Figure 4 and Figure 5.

VI. OPTIMAL PAY AND EMPLOYMENT

Optimalinputmeansyou cannotproduce more atthe same level ofcost, it isnecessarybut not sufficientto maximizeprofit. Ifwe refer towork, then wehave the followingequation tomaximizeprofit:

$$MC_L = MR_L \quad (1)$$
$$P_L = MP_L x MR_Q = MRP_L \quad (2)$$

It is worth hiring as long as marginal cost generated by adding salaries and benefits do not exceed marginal revenue added. Inthis case, theanalysisis to determinethe viability ofhiringadditional staffassumingthere isenoughdemandto buymoreat the sale priceestablished, so the profit ismaximum when themarginalcostequalsmarginalrevenue. Another dimensionis the size ofthe sameinput, or ratherthe costas mentioned,such as senioremployees, mediumandjunior. In order to find the maximum profit we should find out the maximum difference between marginal cost and marginal revenue. According to the Profit Maximization theory, priceelasticity ofdemandis the relative change of demand inrelation to thechange in price [4]. As the curve is much flatter, response of the demand is higher compared to the price and it is for products that are in a competitive market and are not substitutes or products that consumers can dispose of (Elastic curve).

In case the demand curve is vertical, the demand does not react immediately to price changes, which may be due to several reasons such as that supplier monopoly, or the product has a large enough demand so the price cannot decrease, or no

influence substitutes (Inelastic curve). Elasticity has the following formula [5]:

$$E_d = |\%\Delta Q_d/\%\Delta P| \quad (3)$$

A real case will be presented in the following chapters about the optimal pay and employment if a given target of output is set. The given target, for one of the next years, is to produce an output of 28,000 hours. The challenge stands in how the team should be composed with regards to levels SEN, MED, JUN so that the cost will be optimal, the output not being too less, as the demand is known to be 28000h, or too high, in this case a company would enter in the situation of producing on inventory without being able to sell the excess of production. One of the most important fact that needs to be considered is that the levels are not isoquants, as there is a certain extent to which a SEN can be replaced by MED or further SEN by JUN, or MED by JUN. If we had simply considered the ratio of cost vs. productivity for these levels we would have chosen directly to employ only JUN(s). The input data and computation with regards to productivity and cost are shown in Table 5.

Though, this is not valid for a software development company as teams must contain several team members from all of those levels. Beside raw productivity, SEN levels are training and mentoring MED levels, while MED level is training and mentoring JUN levels. According to the HR system, the level with most attrition is the SEN one. As the time passes JUNs are becoming MEDs and MEDs are becoming SENs, hence the SENs are replaced. The cycle needs to be kept running. This is why we came up to a balanced composition within the team. There are three alternatives of team composition that are depicted in Table 6.

Table 5. The raw input data per each level to be used in computing optimal employment for a given target.

Output in 12 months			
	SEN	**MED**	**JUN**
FTE	1	1	1
Cost/1 output	26.8	20.7	13.8
Prod. Factor	0.83	0.81	0.72
Ideal output	1680	1680	1680
Actual output	1394	1361	1210
Cost of input	37270	28169	16692

Table 6. The alternatives and constrain of team composition (x, y, z represents number of FTEs)

Team Formats Constraints (equal or pyramid)			
	SEN	**MED**	**JUN**
FTE	x	x	x
FTE	y	1.5x	2y
FTE	z	2z	3z

Table 7. TCC, Output and Cost/Unit for each of the team composition alternatives.

Output and Cost per various Team Formats (considering a target ~28000 units of output)						
	SEN	**MED**	**JUN**	**Output**	**Cost**	**Cost/Unit**
4-5-4	4	5	5	17220	357092	20.74
7-7-7	7	7	7	27754	575617	20.74
5-7-10	**5**	**7.5**	**10**	**29274**	**565039**	**19.30**
4-8-12	4	8	12	30979	575138	18.57

In Figure 6 it is presented the evolution of the average cost per unit for the different team structures shown in Table 7.

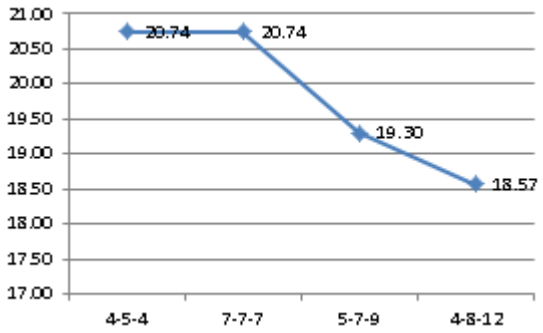

Figure 6. Graphical representation of average cost / unit obtained with each of the team composition alternative.

In Table 7 is depicted what would be the cost and output for several alternatives, using the cost and productivity data from Table 5, while keeping the team composition formats from Table 6. It results that for achieving the target output of 28,000h the best input and team formation would be 5 SEN , 7.5 MED, 10 JUN.

It is considered that this is the optimal employment schema that produces the given target with the minimum cost per output, the value of which is 19.30 EUR/h. This schema produces about 4% product in excess but with a lower total cost than any other alternative and approaches to target output.

VII. LIMITATIONS

Within the current paper it is acknowledged the fact there are certain limitation to be considered. There are three major limitations such as: not enough sampling, inflation ratio over the years, and complexity of work.

Sampling wise we have used samples only over the last 3 years which might be sufficient or statistical significant in order to establish a trend. If we had used more sampling data, for 5 years or more, it

could have established even better statistical relevant trends.

The cost of input is stated for each of the last 3 years, while inflation ration was not taken into account. In EURO zone the inflation was averaging to roughly 3% every year in the last year. Hence, a EURO's value today worth less than a EURO last year, and even more than a EURO two years ago, here the theory and formula about Present Value and Future value is applied. If we had taken in account the PV and FV with the respective inflation ratio the cost of input might have changed. The presented computations have provided different results hence it was taken the limitation as having the inflation 0 for the purpose of applying simply the theory in practice.

The last important limitation is the fact the higher the seniority in the team the more complex tasks they solve. A senior is handling more difficult tasks with higher technical complexity while a junior is handling simpler tasks with lower technical complexity. Even though the output is measured using the same unit of measure, what is behind that unit of measure, namely invoice-able hour of service, is different in complexity. There are certain activities that can be performed only by seniors while not at all by juniors. To name a few there are activities as presentations to end users, trainings, software architecture and framework preparation, code reviews, writing architecture documents. If this difference had been taken in account, the results have were different and, inherently, the limitation of not being able to interchange seniors with juniors when assessing the optimal team sizes/costs for a given target output.

To conclude about limitations, several factors had not been taken in account. The impact of these factors in the outcome of the study is yet unknown, while is sure the results would have been different. Taking in account the entire factors would have required complex computation that might have driven this paper out of the scope of straight forward example of theory put in practice.

VIII. CONCLUSIONS

Stability of employees in a company by increasing salaries higher than average market is a beneficial element in some cases by reducing staff turnover, lower costs resulting from this recruitment process and HR management, and higher productivity from increasing satisfaction.

Not all benefits are clearly measurable, but certainly in terms of economic and decision-making as long as all costs involved with that wage growth and associated with cost savings from stability of employees and compared with the marginal revenue, if productivity growth is associated with a positive balance of profit, then it is worth it. The difference in productivity, wage considering that input only from one level to another depending on skill level, was made following the analysis of two important input parameters, namely the number of employees and salary levels, demonstrated several aspects:

- In terms of profit is better to hire juniors compared with seniors, with the same mention that it is only analyzed the influence of wage costs;
- In this case we had an exceptional situation, demand versus supply is an inelastic equation, means increasing the production is directly proportional with increasing of profit, there was no direct relationship between demand and price;
- Another consideration, but based on uneconomical nature of a direct influencer is the team mix. It's required to maintain a certain mix of employees, types and this mix is demonstrated only statistically trough measurements during the years like: decreasing the response time in cases of extreme urgency, coaching of juniors made by senior team, and growing the innovation process.

A fact unprofitable and directly measurable, but showed in the existing situation is displayed, increase salaries above the market level as some people may generate feelings of false superiority over their own skills, causing migration of staff as a result of inaccurate personal evaluations, the opposite effect expected by the employer trough his actions taken to increase the salary and/or the benefits.

As a final conclusion increase of salary should be made only as the basis of a well-documented economic cost profit analyses, and also based on an analyses of the fluctuation of existing staff in the labor market, as demand and supply.
Nevertheless an internal and regular evaluation of staff is recommended in a transparent way comparing the internal productivity and externally to existing competitors by communicating statistics and analysis of labor market annually through specialized companies.

IX. ACKNOWLEDGEMENT

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