Economic-financial management modeling for biotechnology enterprises in Cuba

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ABSTRACT

Valorization of knowledge generated by the fast advance of science and its marketing has led to the so-called "knowledge-based economy" and as a consequence high-technology (HiTech) companies have emerged. Those based in Biotechnology have some specific features compared to other HiTech sectors. This paper provides a model to structure the economic management of HiTech Biotechnology organizations in Cuba, considering the national economy and the experience accumulated by several institutions from the Scientific Biotech Pole in Western Havana. The model is based on some concepts and proposals, and it addresses key elements, such as: insurance of adequate funding levels for R&D activities and technology replacement, flexible import and export management, the ability to get into very competitive markets and preservation of a highly qualified workforce. It also demonstrates the feasibility to establish this kind of enterprises in the context and regulations already existing in a non-capitalist environment, in the middle of the update of Cuban economy.

Keywords: biotechnology management, economy, knowledge, high technology, enterprise, Cuba

RESUMEN

Modelación económico-financiera de la gestión para empresas biotecnológicas en Cuba. El valor del conocimiento y su uso como mercancía, resultantes del acelerado avance de la ciencia, han originado el concepto economía del conocimiento y, como consecuencia, las empresas de alta tecnología (AT). Las del sector biotecnológico poseen características peculiares con respecto a otros ramos de AT. En tal sentido, se ofrecen conceptos necesarios y se propone un modelo de gestión económica para este tipo de empresas en Cuba, partiendo de la experiencia de varias instituciones del Polo Científico de la biotecnología. Este modelo persigue garantizar niveles de financiamiento adecuados para las actividades de investigación y desarrollo, la reposición de tecnologías, la flexibilidad en la gestión comercializadora, la capacidad de penetración en mercados cotizados y la preservación de una fuerza laboral altamente calificada, entre otros elementos claves. Se demuestra además la posibilidad de implementar este tipo de empresas en Cuba, pese a las regulaciones actuales de su economía, y en concordancia con el proceso de actualización de su modelo económico.

Palabras clave: biotecnología, gestión, economía, conocimiento, alta tecnología, empresa, Cuba

Introduction

High technology (HiTech) enterprises have gained space in the international economy, mainly in developed countries, since only 25-30 years ago. In principle, this category comprises those companies having as key attribute the major component of cost and price of the product, mostly determined by the value of the knowledge invested in the research & development (R&D) phases, production and marketing activities. Sectors usually including this kind of companies are renewable sources of energy, computer equipment and components, new materials, nanotechnology, information technologies (IT; including software) and communications, and biotechnology [1, 2].

In biotechnology, and mainly in the field of human health which is commonly known as the biopharmaceutical (biopharma) sector, HiTech enterprises share very particular characteristics. The most remarkable are: long production cycles, high costs and a significant drop in yields during R&D phases, highly complex manufacturing processes with long cash-to-cash cycles,

very demanding regulatory levels and very dynamic quality control environment, quite aggressive intellectual property policies with relatively short product lifecycles, dependence on highly specialized and motivated staffs. Let us review in brief these properties for better comprehension and further proposal of a model for the Cuban HiTech biotechnology enterprises.

Main properties of HiTech biopharma companies

Long cycle of product development from discovery to market launch

For new drugs, the time for development is much longer than in other complex industries such as aerospace and electronics. It takes 8-12 years for biopharmaceuticals to transit from discovery through clinical development stages to regulatory approval and market launch. It has been reported that only clinical development stages of a biopharmaceutical product

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could last 92-98 months (7-8 years), with an average of 20 months for Phase I, 30 months for Phase II and 33 months for Phase III , and the phase of approval could last 13-16 months [3, 4].

Costs of R&D

In biopharma, R&D are extremely expensive, facing the challenge of long product development cycles and the uncertainty of future returns of the investment. Today, six of the top-ten US companies in overall expenditure on R&D activity operate in the biopharma sector [5]. The typical R&D budget of a multinational biopharma company consumes 15-20 % of gross revenues, compared to approximately 4-5 % for aerospace, telecommunications and electronics industries [6]. In this way, the present R&D expenditure per new molecular entity is estimated by some authors at 1.2 billions of US dollars (USD), representing 1.5 times the 802 million USD in 2000 and more than 8 times the 138 million USD in 1975 [2, 5]. Nevertheless, a more accurate estimate could be the total average R&D expenditure of a company per product launched. Using this measure in the period 1997-2011, the cost of any new drug brought into the market for the world top 12 biopharma companies ranged 3.7-11.8 billion USD [7]. Table 1 shows the average values for the six biggest European biopharma companies for the period 2007-2011.

Moreover, clinical trials activities require the highest proportion of R&D budget in biopharma (65 %) to generate the safety and efficacy data needed for regulatory approval, but add little or nothing to new scientific or technological advances. Preclinical research of one biotech product is more expensive than a traditional pharmaceutical (615 vs. 439 million USD) [3]. Additionally, the late-stage R&D spending pattern became even more asymmetric when a drug fails in late stage development, where there is little to nothing to be saved from failure.

Productivity in biotechnology R&D

In the last years, biotech R&D productivity became lower compared to 1980's-90's decades, controversially with the high level of funds spent, as shown by the 2011 Deutsche Bank report when looking at the seven largest European drug makers [8] (Table 1). Despite the high level of funding for R&D, only two companies reached more than one drug approval per year in average.

Other studies have determined that the transition probabilities of a biotechnology product from Phase I to II is around 84 %, from Phase II to III is 56 % and from Phase III to Approval is 64 %. These results render an approximate 30 % overall clinical approval success rate for a biotech product, higher than the 22 % rate observed for pharmaceutical non-biotech products [3, 9].

Cash-to-cash cycle

This is a measure of how long it takes to a product to move through the supply chain. In biopharma it is usually 3-fold that of any other industry and is dominated by supply chains and quality release times (both for goods and drug products). In some cases, these periods comprise over 90 % of the overall time to produce a batch of material. This fact ties up hundreds of million USD in inventory [10]. Any measure to reduce these times will have a significant effect over the costs and overall process yields.

Technologies and manufacturing processes

In such companies, the technologies and manufacturing processes are far complex and based on manipulating living organisms. In many cases, this fact renders processes unique and specific for each product and makes that value added to the product, through the knowledge generated during development and manufacturing stages which is also very high, even comparable with that brought at the R&D stages.

Degree of quality regulations

Quality standards for HiTech companies are very high, predetermined by the same competition for innovation and differentiation [11]. They are pretty dynamic and evolve with the advance of science and technology, particularly for new drugs, but also with new approaches applied to existing products. Properties such as aggregation, concentration, and potency continuously increase in importance along with the flow of advancements in pharmacokinetics, physiology, and precision measurement. Therapeutic proteins, as vaccines and monoclonal antibodies, are good examples of this fact. For many new products, especially in biotechnology, new quality standards tend to set technological limits sometimes unreachable by older methods. This imposes a high technological turnover and increases the investment required to improve analytical and production infrastructures.

Product life cycle

In Biopharma this is relatively short. Once a biopharmaceutical makes its way into the market, it takes 7 to 10 years before patent expiration. For example, a new model of commercial aircraft could be in exploitation almost 35 years after launch, with several line extensions and only the manufacturing company competing for market share. But a typical drug will lose 80-90 % of its sales due to generic competition within six months of patent expiration in the US [6]. This fact renders the biopharmaceutical sector more dependent on intellectual property policies and strategies than other HiTech industries, with a significant role for proprietary and undisclosed technologies (*know how*).

Production-derived knowledge

Thereon, it may be considered that the knowledge generated at the different stages of production and

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Table 1. Yields of R&D funding (in billion USD) determined as number of new drug approvals for the seven largest European biopharma companies in 2007-2011

Company	R&D spend (billion USD)	New drug approvals
Roche	35.1	2
Sanofi	28.7	5
Novartis	28.7	15
GlaxoSmithKline	28.3	16
AstraZeneca	22.5	3
Bayer	10.6	3
Novo Nordisk	7.2	1

which allows transforming raw materials (*e.g.*, cells, substances, energy, etc.) into the desired product, constitutes a mean of production itself. Knowledge integrates as part of the entire productive capacity that is needed to produce both consumables and additional capital goods.

Mechanisms have been generated within the capitalism to privatize the knowledge, mainly through intellectual property regulations. But, tacit knowledge is inherent to people itself and nothing prevents that it could be transmitted by individuals of a company to another, recombining by the phenomenon of labor force flow, due to best offers of work conditions or remuneration. Thus, HiTech enterprises workers will increase their qualifications, with the accumulation of new knowledge, already generated by them or previously assimilated there. This process supports the trend to continuously increase their value in the labor market.

Highly qualified and motivated personnel

All previous facts establish for biotechnology companies, and in general for HiTech enterprises, the need to maintain a highly motivated, creative and qualified personnel in the activity of innovation. This is required, not only for the stages of basic research, but also in the stages of development, manufacturing, marketing, and quality control, including areas such as business, information and human capital management, among others.

The most direct consequence of this phenomenon is that the costs in workforce for this type of companies, usually constitute more than 50 % of the total production costs. As reference we can mention that the US biopharmaceutical sector comprises around 650 000 employees, with an average annual salary exceeding 95 000 USD [6]. According to the results of a study performed in several European countries, the Hays Consulting company concluded that the biopharma sector, as any other, pay special attention to salary policies, which is well above the average, with over 95 000 € and 71 000 € per year base salary compensation in senior and intermediate posts, respectively [12]. For this reason, the management of human capital and its related knowledge acquire a new dimension at the biopharma sector, to guarantee maximum stability and an efficient exploitation [13].

According to the 8th Annual Report and Survey of Biopharmaceutical Manufacturing Capacity and Production carried out by BioPlan Associates in 2012, the main factor creating manufacturing capacity constraints was the inability to hire new experienced technical and production staff [14]. It also identified that staff acquisition was the biggest budget growth area in biotech companies, increasing 3.5 % compared to 2011. The most difficult job positions to fill were development professionals, especially process engineers and up- and down-stream process development specialists.

*T*he emergence of HiTech state-owned enterprises in the Cuban biotechnology sector

The premises for the development of the Cuban biotechnology industry were created after the revolutionary triumph of 1959, led by the political vision of our Commander in Chief Fidel Castro Ruz [15]. The main factors that have been decisive for the development of these institutions include: the sustained educational work and improvements in public health reached after the Cuban Revolution until now, the priority given to the development of scientific and technical activity with a vision of linking them to the economy, the creation of scientific poles throughout the country, and particularly the Western Havana Scientific Pole for biotechnology, and the political will to invest in the development of these institutions for the purpose of completing the research-manufacturing-marketing cycle. These regardless the economic difficulties that arose after the US embargo in 1962 and the special period from 1990 on. The experience in our country for more than two decades is unique, and without any doubt, successful [16-18].

Cuban biotechnology institutions are research and production organizations owned by the State that connect science with economics, generating positive cash flows and high productivity levels. These facts support collaborative relationships, with an optimized use of resources and potentialities of each institution, instead a competitive and excluding environment.

The sector shows a tangible and growing impact on social niches and the production of consumer goods, especially in the health and education systems, but can also establish productive chains with other sectors of the economy (construction, chemicals, electronics, IT, mechanical, etc.).

As was mentioned above, biopharmaceuticals usually have a short life cycle, implying medium term development activity for new products to guarantee a broad pipeline, which could be combined with the short-term commercial operations. Therefore, these companies are based on innovative products, with highly internalized R&D activity that is funded as part of the expenses associated with income levels (variable costs), and in some cases managed as investment at risk.

In contrast to leading developed countries, this kind of enterprise in Cuba is mainly oriented toward the foreign market, *i.e.* export-oriented, with capacity to direct and manage the export activity. This forces these companies to comply with external quality standards and market regulations, and to be capable of answering variable requirements to remain competitive.

At the same time, R&D, production and marketing in these organizations have a high technological level, showing increased rates of equipment replacement and investments in new capabilities.

Furthermore, the Cuban biotechnology organizations employ highly qualified workforce, which requires high levels of creativity and motivation, as in other HiTech industries. This human capital should be preserved even under adverse market situations, implying a high proportion of labor costs compared to traditional companies.

In summary, the Cuban biotechnology sector is basically a new type of research-manufacturing organization, owning at the same time general traits that distinguish all socialist states' enterprises, as well as those of the world's biopharma sector.

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An economical model for the Cuban biotechnology enterprises

From the general considerations outlined above, a model of economic management can be proposed for this new type of HiTech institution within the national economic scenario, the Cuban HiTech biotechnology enterprise [15, 19].

In order to fit the general requirements established for such an advanced enterprise system in Cuba (*i.e.*, profitability, reliable accounting, positive results in internal controls, and others), these companies must have low cost of goods per revenue (*e.g.*, lower than 0.5) and high productivity as performance threshold. Productivity was calculated as the relationship between net incomes (also defined as Gross Added Value, VAB) and average number of employees. A productivity threshold value was set to 50 000 monetary units (UM)/employee at the present CUC/CUP exchange rate (1:1). This number is five-fold the value for the national average and almost twice the value obtained for sectors with the best performance in the country (*i.e.*, communications and financing, insurance, real estate and business services) [20].

Also these organizations should have full cycle operation, including scientific research, development of new products, production processes of high complexity and quality levels, with a projects' portfolio and innovative products at various R&D stages. They should be also supported by adequate intellectual property exploitation and show a sustained export performance to various destinations markets, not only able to finance their expenditures but also to provide utilities. It was considered that such institutions should account for a highly skilled workforce, above 60 % of the staff having high academic, scientific or technical qualification degrees.

A system approach was used, considering as integral elements of the model the data input (variables and parameters, policies and assumptions), its processing (relations between components) and presentation of results (output variables). These improve effectiveness in developing financial models. The approach comprised a structural analysis, according to which it seeks to find a result (output or endogenous variables) by applying mathematical operations to relations (processes) that occur between the elementary variables (input or exogenous variables). Using such an approach, a linear economic model was developed, that consists in a series of outputs expressed in terms of intermediate and outcome variables that are used to analyze a business situation, which can be generalized in the following expression: $y_1 = f(x_1, x_2, x_3, ... x_n)$.

In the model, some fees and percentages are defined as exogenous variables. Their values are only proposals, obtained in some cases from the current national legislation, international practice or national experience gained during several years of work of this kind of organization. Appendixes 1 and 2 describe the parameters considered as exogenous variables for the model (input, Appendix 1) and all the linear relationships and endogenous variables (output, Appendix 2).

Taking into account these relationships and once the taxes values were defined (see appendixes), it is possible to obtain the following fundamental analytical relationship between net income (VAB) and exogenous variables: overall income (F), income by exports (F_{CUC}; measured in Cuban convertible currency, CUC), income by domestic sales (F_{CUP}; in Cuban pesos, CUP), costs of goods (COG) and exchange rate (TC):

$$VAB = 0.889 \times (F_{CUC} \times TC + F_{CUP}) - 0.911 \times (COG_{CUC} \times F_{CUC} \times TC + COG_{CUP} \times F_{CUP}) \quad (1)$$

$$or \ \ VAB = F \times (0.889 - 0.911 \times COG) \quad (2)$$

Several tax contributions are considered according to what was stated in the Cuban Act 113 of the Tax System [21]. Taxes related to the *Territorial tribute for local development (IMTT)*, *Use of labor force (IMFT)* and *Contribution for social assurance (CSA)* should be defined every year, and were deduced for the present model as 5 % of revenues and 12 and 10 % of wage funds respectively.

Under present exchange rate conditions (1 CUC = 1 USD = 1 CUP), the companies with the greatest export don't have any benefit in terms of their expenditure budgets and salary funds with respect to enterprises that conduct most of their turnover in local currency. One possible solution to eliminate or mitigate these limitations is to gradually devalue the CUP/CUC exchange rate in the operations of export-oriented companies. For this purpose, the model includes a currency conversion rate (TC), specific for this kind of enterprises. This measure has already been employed in other sectors as tourism [22], and provides the ability to assess more realistically the internal market relationships with the external sector.

Different alternatives can be implemented for budget allocation of operating expenses in foreign currencies. One of them is to allocate a budget in CUC (or directly in some foreign currency) as planned by model's calculations for these activities. This allows companies to request the purchase foreign exchange to the bank to carry out required imports and payments for services. Another way is to establish unique accounts in CUP from the exchange rate adopted for these companies, and exceptionally allow these companies to request bank purchase of foreign exchange for their expenses according to the approved plans taking a CUP conversion rate, similar to the system implemented already for tourism [22].

Operating expenses

The *Expenses for expanded reproduction* (GCP) are deducted from the total annual revenue (F) according to the planned growth rate and index of cost per revenue planned for the coming year (including purchases of raw materials, energy costs, received services related to production such as water and sewer, community, communications, etc).

Also from the revenues is created the necessary fund for *inward investments* (GIM), comprising up to 5 % of revenues. This is intended to guarantee the technological renewal and redundancy in agreement with market demands (modernization and retrofit), taking into account the rapidly-evolving standards of quality and technological obsolescence, implying a high depreciation rate for the equipment. In agreement with provisions of Act 113 of the Cuban Tax System [21], it should be considered for GIM: depreciation and amortization, conservation and maintenance of machinery and equipment, and other

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assets involved in obtaining the utility (*e.g.*, the capital repair of an asset).

The model includes an internal fund for *overall and administrative expenses* (GGA), up to 10 % of operating expenses. According to the Cuban Tax System [22], these expenses could be distribution and sales, general and administrative, operating, financial, for the creation of mandatory provisions, travel at home or abroad, when necessary, and directly attributable to the business of the institution, the cost of advertising and publicity as related to its corporate purpose or business, the amounts paid for the lease of goods needed for the activity or to establish technical provisions, working capital, and representation expenses.

A percentage of revenues (GID; 5-10 %) is allocated for *R&D activity*. Like marketing expenses, but unlike capital expenditures, these expenses are usually subtracted directly from revenues every year in the international practice of HiTech companies. Therefore, accountants treat R&D spend as an expense rather than an investment, though there is continuous debate over whether this is the correct classification. Even the salaries of researchers and personnel involved in R&D activities are generally regarded as expenses in the R&D category. In our model, this was considered a *venture fund for advanced R&D* projects, of potential high social impact, mainly oriented to clinical stage of innovative and "me-too" product development, optimization of the production process, development and assimilation of new technological platforms (analytical, production), in which the rate and time of return can be already defined. In addition to the usual operating expenses, this fund includes the expenses to purchase the equipment and technology specific for R&D, international collaboration, payments for research and development services, intellectual property assurance, and similar.

Profits

From the obtained *profits (U)*, a fund is created (up to 20 %) which is managed by the enterprise for *middle to long term, higher risk projects (FINID)*, mostly basic research, new therapeutic concepts and target identification, among others. It should be considered also to provide funding to external research institutions, including academic groups, which collaborate to address projects of interest for the company.

A tax over profits (IMU) is also provided in agreement with the Tax System Act [21]. In this case, a 35 % is considered, as the maximum value established.

A provision for the establishment of respective funds to *reserves and insurance (FAP)* and for the creation and operation of the *High Level Management Entrepreneurial Organization* (OSDE) BioCubaFarma is also deducted from profits. This would create a level of protection against unforeseen changes in the market and the long R&D cycles, preserving the workforce. Additionally, it will make possible to allocate funds to finance educational institutions of interest for the sector, given its contribution to the development of human resources, such as vocational senior high schools, technological schools and universities in related specialties. It would also allow implementing centralized investments and financing, external to the sector's institutions in the research lines of interest. Among these, the possible use of *profits obtained by*

surpassing the sales plan and cost savings as a fund intended for investment, development and stimulation of workers was assessed by improving working and life conditions.

Noteworthy, the structure of expenses proposed in this model links R&D and internal investments directly to the enterprise overall turnover. Moreover, it allows total cost and operating expenses to decrease mainly by lowering production-related and overall expenses, and avoiding the natural trend to carry out this goal by scarifying funds for R&D and internal investments, which put at risk the long-term strategy. At the same time, this structure guarantees the enterprise financial support for those projects with higher risk from its profits, increased funding level for those projects at most advanced development stages and with more potential for social and economic impact.

Every budget mentioned above can be formed in CUP; however, the company should be able to exchange part of it in foreign currency for external operations. The maximum amount allowed for such money exchange is taken proportional to the ratio between revenues in foreign and local currency generated by the enterprise.

The ability to manage these funds as the company requires will allow better planning, with enhanced efficiency, dynamism and flexibility for enterprise performance and its responsiveness to market demands.

Workers remuneration

The *fund of basic salary (FOS)* is formed from overall revenues**,** which is considered as part of the total costs (as labor costs) and will be a predetermined percentage of net income VAB (15-30 %). In this way, the basic salary of employees is correlated with the efficiency of results (cost to productivity ratio).

Also from a percentage of profits (15-30 %), a fund *for salary stimulation (FES)* is created to complement the basic wage fund. This incentive package links worker incomes with maintenance or increase of efficiency levels, expressed as low relative costs and utilization of potential savings. Moreover, it increases profits, giving major stimulations to those companies with the highest export turnover.

The implementation of payment systems for the distribution of these funds must be determined by internal regulations of the company, previously consulted and approved by the OSDE BioCubaFarma, enhancing those aspects that enterprise managers consider of highest priority, after agreement with workers and giving freedom to the companies for approval staff draw. Labor force remuneration systems should be designed based on the concept of establishing job post profiles and adjusted to the specificities of these companies.

Implementing the model

In order to illustrate a practical application of the proposed model and to analyze the results, an exchange rate of CUC to CUP (TC) value equal to 7 was used, taking into account that this value is in the range (6 to 9) that has been employed for other economic sectors [22]. For this case, the new threshold value of productivity equivalent to that established previously with TC = 1 using equation 1 can be calculated. It would now be 200 000 CUP, instead of 50 000 CUP. As

reference for international exchange rate the equivalence between the Cuban Convertible peso (CUC) and US dollar is considered as 1 (1 CUC = 1 USD).

It is advisable not to use very high exchange rates, which could create temporary economic imbalances, especially in the absence of sufficient market space to facilitate the equilibrium of prices. The introduction of such exchange rate is considered only for export enterprises, keeping the sales for domestic market of these companies at 1 for TC. This because of the fact that, during the initial period of model implementation, a higher exchange rate will not fit for most institutions allocating their products or services in the national market. For this reason, it is advisable to avoid the rise of prices in the internal relationships of our model enterprise by including non-exporting and budgeted institutions.

A simulation at conditions explained in the previous section is shown in table 2 for a study case of a national biotechnology company with a work force (FT) of 1000 employees, annual revenues of 65 million CUC (F_{CUC}) and 60 million CUP (F_{CUP}), a cost of goods sold per revenue (COG) of 0.3 and 0.2 in CUC and CUP, respectively, and an annual growth rate (TCA) of 5 %. Also we assumed for the calculation of the net income (VAB) a produced, but not commercialized, value of 20 % of their production costs in product not yet billed.

As observed in table 2, high productivity values are achieved, both calculated from net income (more than 211 000 CUP per employee) as from the profits generated. Moreover, the company shows a total cost per revenue of 0.78 (that includes all current production, R&D, general and administrative and small inward investment plus basic salary fund).

The defined respective tax for each item was established as upper limit for expenses in foreign currency, of about 5 % of income in foreign currency (F_{CUC}) for R&D fund (GID) and inward investments fund (GIM) respectively, 10 % of total expenses for overall and administrative expenses (GGA) and 10 % of profits for discovery stage R&D projects fund (FINID). Under these conditions, amounts that guarantee an adequate level of funding for these activities were obtained: 3.25 million CUC for GID, 1.26 million CUC for FINID, 3.25 million CUC for GIM and 5.09 million CUC for GGA, that represents 83 % of income in that currency (F_{CUC}). Profits reached 16 % of total revenues and the maximum of total salary remuneration (FOS + FES) was 24 % of productivity value.

From the relationship expressed in equation 1 and shown in figure 1 we can conclude that the modeled company has great strength on its performance, supported by the wide range of costs of goods and revenue levels allowed without productivity flaws. The value of net income and productivity threshold is shown. The conditions that guarantee costs of goods per revenue and income values above threshold can be also determined.

Even with relatively high costs of goods per revenue for these kinds of enterprises (up to 0.7) it is possible to maintain the productivity above the threshold if the revenues reach over 800 millions CUP (that is, 100 million CUC from export and 100 million CUP from the domestic market). It should be also remarked

that for revenues figures below 300 million CUP it is not feasible to reach the threshold values of net income and productivity for any value of costs of goods per revenue (COG) over 0.2. The slopes obtained from the linear fit of lines for different values of costs of goods sold per revenue stand for the fraction of each monetary unit received as income that goes to the net income (Figure 1).

Figure 2 shows that both the net income, as profit, and total costs per revenue have the same behavior when varying the costs of goods sold per revenues both in CUC and CUP. Obviously, the costs of goods sold per revenue inversely correlate to the net income and profit. It can be seen that the breakeven point is achieved still with high values of net income (130 million CUP), at costs of goods per revenue (COG) of 0.46 (both in CUP or CUC) and operative production costs (COP) lower than 1. As a result, we can say that these companies have a high strength in

Table 2. Simulation of economic management for a hypothetical Cuban biotech company using the proposed*

Item	Amount	%	Taxes
Total revenues, in CUP	515 000 000		Exchange CUP/CUC
in CUC	65 000 000		TC
in CUP	60 000 000		7
		%	**Reference variable**
In process production, in CUP	54 075 000	20	GCP
No. employees	1000		
Annual growth rate		5	F
Total costs per revenue	0.78		
Operating costs per revenue	0.69		
Cost of goods per revenue	0.53	-	-
in CUC	0.30		
in CUP	0.20		
Total operating expenses, in CUP	357 638 889	69	F
Production, in CUP	270 375 000	53	F
From this in CUC	39 375 000	61	F_{CUC}
Advanced R&D projects, in CUP	25 750 000	5	F
From this in CUC	3 250 000	5	F_{CUC}
Inward investment, in CUP	25 750 000	5	F
From this in CUC	3 250 000	5	F_{CUC}
Overall and administrative, in CUP	35 763 889	10	GC
From this in CUC	5 097 222	10	GC_{CUC}
Net income (gross added value)	211 436 111	41	F
Salary fund, in CUP	42 287 222	20	VAB
Average Salary, in CUP	3 524		
Tax for use of labor force, in CUP	5 074 467	12	FOS
Social assurance contribution, in CUP	4 228 722	10	FOS
Social contribution, in CUP	-	0	F_{CUC}
Territorial contribution, in CUP	25 750 000	5	F
Total expenses & contributions, in CUP	434 979 300	84	F
From this maximum in CUC	52 375 000	81	F_{CUC}
Profits, in CUP	80 020 700	16	F
From this in CUC	12 625 000	19	F_{CUC}
Tax over profits, in CUP	28 007 245	35	U
Salary stimulation fund, in CUP	8 322 153	20	U
Basic research projects, in CUP	8 002 070	10	U
OSDE BioCubaFarma, in CUP	4 001 035	5	U
Assurances and provisions, in CUP	24 006 210	30	U
Productivity (per VAB), in CUP	211 436	-	-
Productivity per revenue, in CUP	515 000	-	-
Productivity per profits, in CUP	80 021	-	-

* The model used a template generated in an Excel spreadsheet. Values fixed as input (white) and relationships defined as output (gray cells) are shown. See legend in Appendix 1.

terms of earnings, having a wide operating margin over production costs and revenue levels in both currencies, without falling into losses.

Values of net income related to revenue (VAB/F) obtained under modeled conditions (20-40 %) perform among the best, compared to those reported for such kind of companies worldwide. For example, in 2012, this value was 23.2 % for Amgen, 19.2 % for GlaxoSmithKline, 14.8 % for Novartis and 14 % for Merck and Co. [23].

The use of an exchange rate greater than 1 introduces some risk of an increase of product prices that these companies supply to domestic market (inflation). This effect on the National Public Health System, the main user for biopharma companies in Cuba, can be avoided by accounting the revenues from domestic market (F_{CUP}) as a non-operating expense and social contribution. This will help also to solve the contradiction between the need to establish reference prices for the domestic market in line with the international market prices (and maximize export earnings), and the logical need that the acquisition of these products by the budgeted institutions in the country does not overload the state budget. Assuming a social contribution equal to the amount of total revenues from the national market, equivalent to subsidize the consumption of the national health system, profits decrease down to 4 % of total revenues. From figure 2 it can be observed that profits become null at operative costs of production (COP) values as low as 0.35 (in CUC or CUP). This effect could be partially damped if applying differentiated tax policy as allowed in Tax Act 113 [21]. Also by decreasing the tax over profit (down to 10 %) and increasing the fractions devoted to salary stimulation and basic research funding, up to 40 % each for the analyzed example, while decreasing the contributions to the OSDE BioCubaFarma and formation of reserve funds.

Figure 3 compares the behavior of different variables of the model (GID, GIM, GGA, FINID and GID + FINID) at different values of the total COG for the constant values of revenues in CUC and CUP established in table 2.

In both cases, funding levels are obtained for inward investment fund (GIM) independently from the value of COG, while overall and administrative expenses (GGA) increase and funding levels for basic projects decrease equivalent to profit reduction. Nevertheless, R&D fund for advanced projects (GID) and the total research and development funding (GIM + FINID) decrease with the increase of costs of goods per revenue (COG) for conditions shown in figure 3A. But, paradoxically these funds increase in the case represented in figure 3B.

As mentioned before, the model provides funds for basic salary (FOS) from 20 % of net income (VAB) and for stimulation wage (FES) from 20 % of profit.

The full salary compensation fund (FST) is proportional to the net income and profits; in other words, proportional to turnover and efficiency. Figure 4 shows the decrease of basic and stimulation salary funds, proportional to the increase of the overall COG, because of reduced net income and profit.

Obviously, the stimulation fund (FES) is null when COG reach 0.46, because no profit is obtained. This figure also represents the relationship between the total
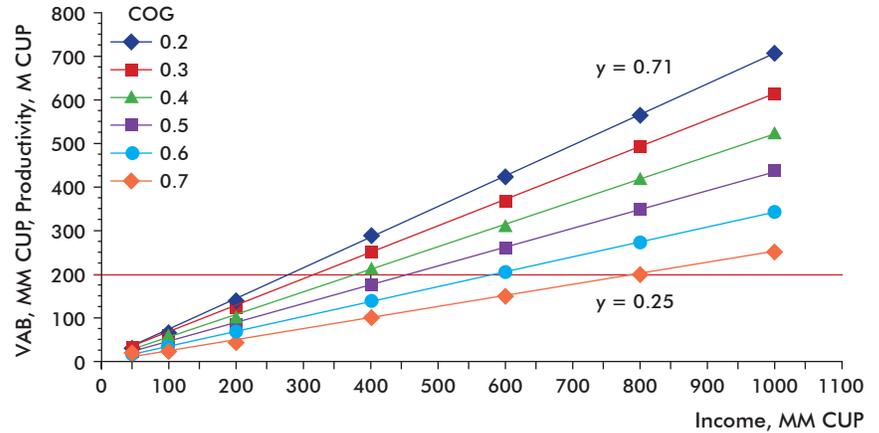

Figure 1. Relationship between productivity and net income (VAB) to the level of company revenues using several values of cost of goods sold per revenue (COG) in agreement with the proposed model for Cuban biotechnology enterprises. M CUP and MM CUP: thousands and millions of Cuban pesos, local currency, respectively. The horizontal red line represents the threshold value of productivity for TC = 7 (200 000 CUP/employee) equivalent to that established previously with TC = 1 (50 000 CUP/employee) using equation 1.

average wage (FST) vs. productivity with the increase of COG, with a maximum value of 0.25 at a 0.1 COG and then decreases with the increase of these costs. As expected, the largest amounts of total salary fund (FST) are obtained with a decrease in COG, mainly at the expense of higher values of net income that imply higher rates of productivity and operative fund for basic salary (FOS).

Average base salary increases proportionally with revenue levels, and the rate of this increase is related to the values of costs of goods sold per revenue, being greater as these are reduced.

These wage levels would ensure the basic needs of the staff of such companies, leveraging the social status of these workers, who are among the most productive

23. YChart: The Financial Terminal of the Web [Internet]. c2013 [cited 2013 Aug 18]. Available from: http://ycharts.com/companies/AMGN
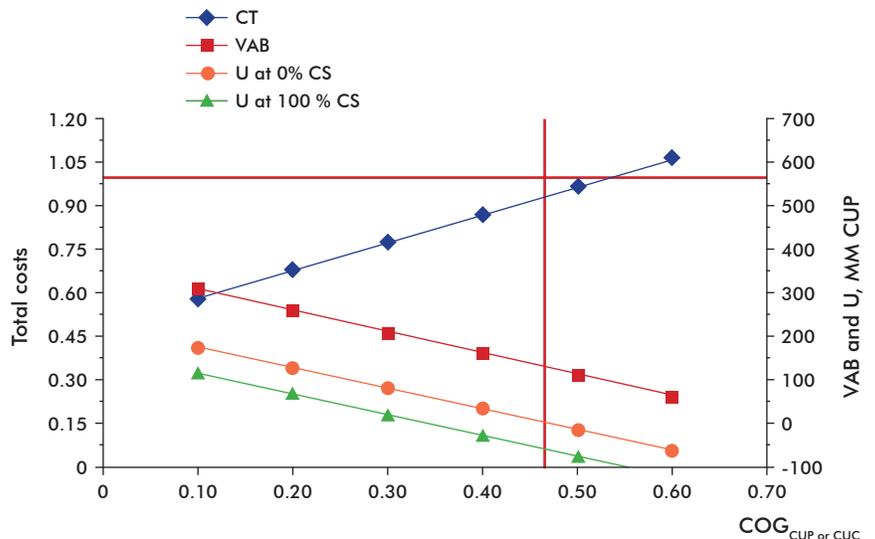

Figure 2. Relationship between total costs, net income and profits with production costs of goods both in CUC or CUP calculated according to the proposed model for Cuban biotechnology enterprises. CT, VAB and U are total costs, net income and profits for different values of COG in CUP and CUC. CS = 100 % indicates profits values when F_{CUC} is considered as contribution. Horizontal red line denotes the total costs per revenue (COG) equal to 1, and the vertical one stands for COG values in which the profit is zero for defined conditions (breakeven point). MM CUP: millions of Cuban pesos, local currency.
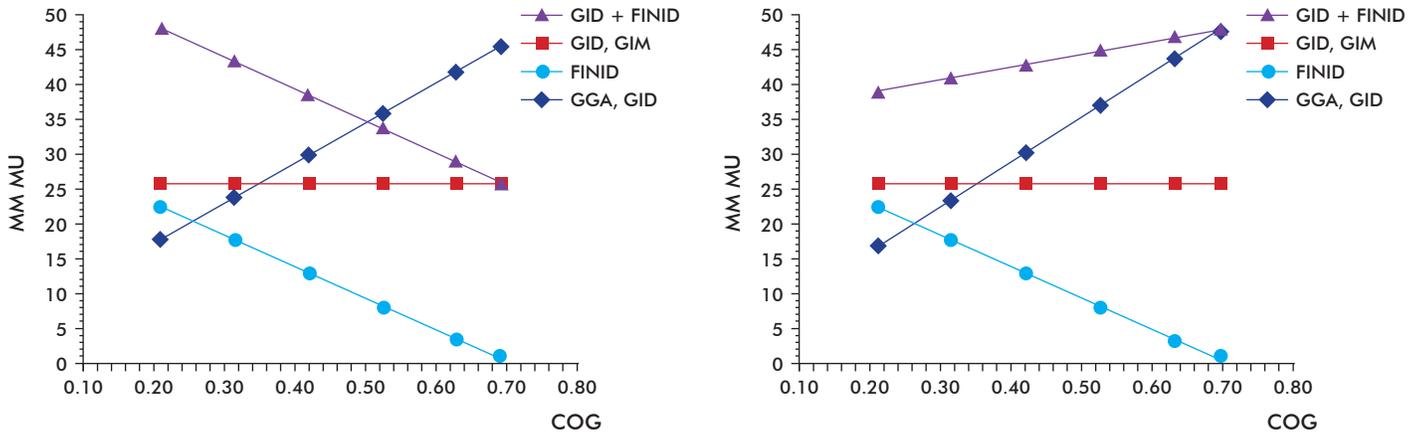
Figure 3. Relationship between total percentage of revenues (GID), internal fund for overall and administrative expenses (GGA), fund for inward investments (GIM), R&D discovery projects fund (FINID) and GID + FINID, with total production costs of goods (COG), in the economic model for Cuban biotechnology enterprises. A) COG calculated taking GID as 5 % of F according to the proposed model. B) COG calculated taking GID as 10 % of overall and administrative expenses GGA. M MU: millions of monetary units

forces of the country, with other existing sectors of our society nowadays.

Concluding remarks

The rapid advance of science and technology has led to new realities, both in the economic sphere, as in social relationships. These phenomena have led the so called "knowledge-based economy" and the companies that have emerged as a result have been classified as HiTech, and the biopharmaceutical industry is included among them. This phenomenon has also led to the appearance of new production relationships and highly skilled productive forces, partially owners of knowledge necessary for production of high technology goods or services and whose value is superior to their similar in other types of business and industry.

Moreover, although it has begun to draw some level of historical experience of socialist enterprise models, we can say that there is little record of the establishment and successful operation of high-tech enterprises of socialist economies, not to mention the underdeveloped countries.

Cuba is consolidating its biopharmaceutical industry, by grouping several HiTech biopharma enterprises, given the favorable conditions created by the Revolution and the political vision of our Commander in Chief Fidel Castro Ruz. Until present day, the experience has shown their potential for success, creating institutions with characteristics such as high R&D level, major export capacity, high indicators of productivity and profits, and a highly qualified and motivated workforce. These enterprises face in their design and management the same challenges of all socialist state owned enterprises together with requirements of the "knowledge-based economy".

The financial and economic management model proposed in this paper for such enterprises promotes a high level of innovation, supported by a powerful
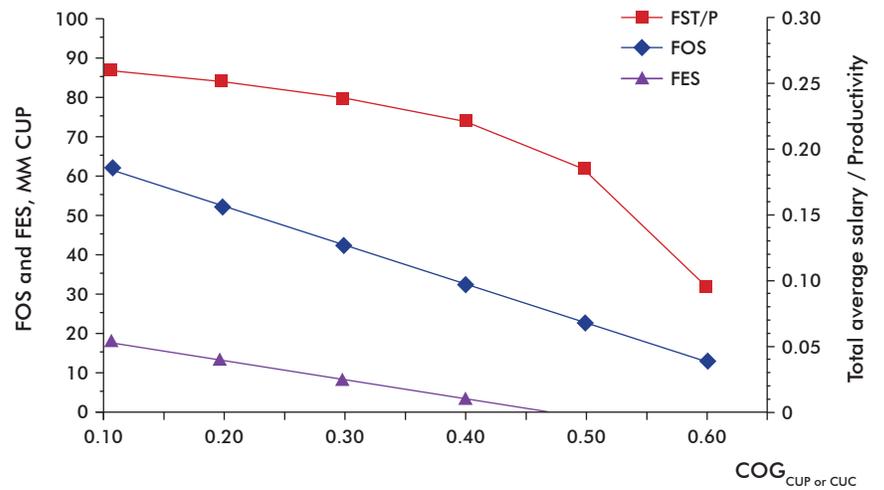
Figure 4. Relationship between basic (FOS) and stimulation (FES) salary funds and rate of total salary fund per productivity (FST/P) with the cost of goods sold per revenue (COG) both in CUC or CUP, according to the proposed model for Cuban biotechnology enterprises. The relationship is presented with and without social contribution accounting F_{CUP}: (income by domestic sales in Cuban pesos, CUP) as non-current expenses. MM CUP: millions of Cuban pesos, local currency.

scientific and technical research (both internal and external), market-oriented activity, high level of investment in technology and expansion of capabilities to meet markets' demands. It also boosts and supports successful compliance with the constantly evolving quality standards and the high cost of labor force, to ensure the maximum stability and performance required to be competitive in the international arena.

The R&D funding scheme proposed in this model allows to reach the average value of international standards for this kind of enterprises, (*i.e.*, 10-20 %) of revenue devoted to R&D activity in a remarkably different scenario of social retribution and quite different economical balances.

Appendix 1: Exogenous variables (input) defined in the model

F_{CUC}: Income by export (Cuban convertible currency, CUC)
F_{CUP}: Income by domestic sales (Cuban pesos, CUP)
TC: CUC to CUP exchange rate
TCA: Annual growth rate (%)
FT: Number of employees
COG_{CUC}: Costs of goods per revenue in CUC
COG_{CUP}: Costs of goods per revenue in CUP
T_{TVP}: Rate of produced value (%)
T_{GID}: Rate of R&D expenses for advanced projects (%)
T_{GA}: Rate of overall and administrative expenses (%)
TG_{IM}: Rate of inward investments (%)
T_{FOS}: Rate of operative salary fund (%)
T_{IMU}: Rate of tax over profits (%)
T_{IMTT}: Rate of territorial contribution (%)
T_{CSA}: Rate for social security contribution (%)
T_{IMFT}: Rate for use of labor force (%)
T_{FES}: Rate for salary stimulation fund (%)
T_{FINID}: Rate for R&D discovery projects fund (%)
T_{FAP}: Rate for assurance and provisions (%)
T_{OSDE}: Rate for contribution to OSDE (%)

OSDE: High Level Management Entrepreneurial Organization BioCubaFarma

Appendix 2. Endogenous (output) variables and linear relationships defined and used in the model

Total revenue: $F = F_{CUC} \times TC + F_{CUP}$
Operating production expenses: $GCP = (COG_{CUC} + COG_{CUP}) \times (TC \times F_{CUC} + F_{CUP}) \times (1 + TCA)$
Production expenses in foreign currency: $GCP_{CUC} = COG_{CUC} \times (F_{CUC} + F_{CUP}) \times (1 + TCA)$
In process production value: $VP = GCP \times TVP$
R&D expenses advanced projects: $GID = T_{GID} \times F$
Inward investment: $GIM = T_{IM} \times F$
Overall and administratives: $GGA = (GCP + GID + GIM) \times (T_{GA} / (1 - T_{GA}))$
Total operating expenses: $GC = GCP + GID + GGA + GIM$
Net income (Gross added value): $VAB = F - GCP - GID - GGA - GIM + VP$
Operating salary fund: $FOS = VAB \times T_{FOS}$
Average salary: $SM = (FOS / FT) / 12$
Cost of goods per revenue: $COG = GCP / F$
Operating costs per revenue: $COP = GC / F$
Total costs per revenue: $CT = (GC + FOS) / F$
Tax for use of labor force: $IMFT = FOS \times T_{IMFT}$
Social security contribution: $CSA = T_{CSA} \times FOS$
Territorial contribution: $IMTT = F \times T_{IMTT}$
Social contribution: $CS = F_{CUP} \times T_{CS}$
Total Expenses & Contributions: $GT = GC + FOS + IMFT + CSA + CS + IMTT$
Total Expenses in foreign currency: $GCP_{CUC} + (T_{ID} + T_{GA} + T_{IM}) \times F_{CUC}$
Profit: $U = F - GT$
Tax over profits: $IMU = U \times T_{IMU}$
Salary stimulation fund: $FES = U \times T_{FES} \times F_{CUC} / (F_{CUC} + F_{CUP})$
R&D discovery projects: $FINID = U \times T_{FINID}$
Contribution to OSDE BioCubaFarma: $OSDE = U \times T_{OSDE}$
Assurances and provisions: $FAP = U \times T_{FAP}$
Productivity (per VAB): $P = VAB / FT$
Productivity per revenue: $P_F = F / FT$
Productivity per profits: $P_P = U / FT$
Total fund of salary: $FST = FOS + FES$