

# EDUCATION CAPACITY MANAGEMENT FOR IT WORKFORCE IN DEVELOPING COUNTRIES

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Developing countries that have become major destinations for globally distributed IT work have experienced significant economic gains from these activities. Since IT work is primarily knowledge based, the gains from GDW can be sustained only if there is a reasonable balance between demand for and supply of IT labor. Using the system dynamics methodology, we develop a stylized model of the educational capacity of a developing country and analyze its sensitivity to different values of policy variables. The long lead times associated with adjusting education capacity, coupled with short term variability in industry labor needs, implies that we understand the dynamics of imbalance between labor demand and supply. This understanding helps in long term planning for educational capacity, so as to meet the needs of the IT sector in a sustainable and efficient manner. The impact of different policy options can also be studied by using the model as a decision support tool.

## Keywords:

Knowledge work, education capacity, system dynamics, planning.

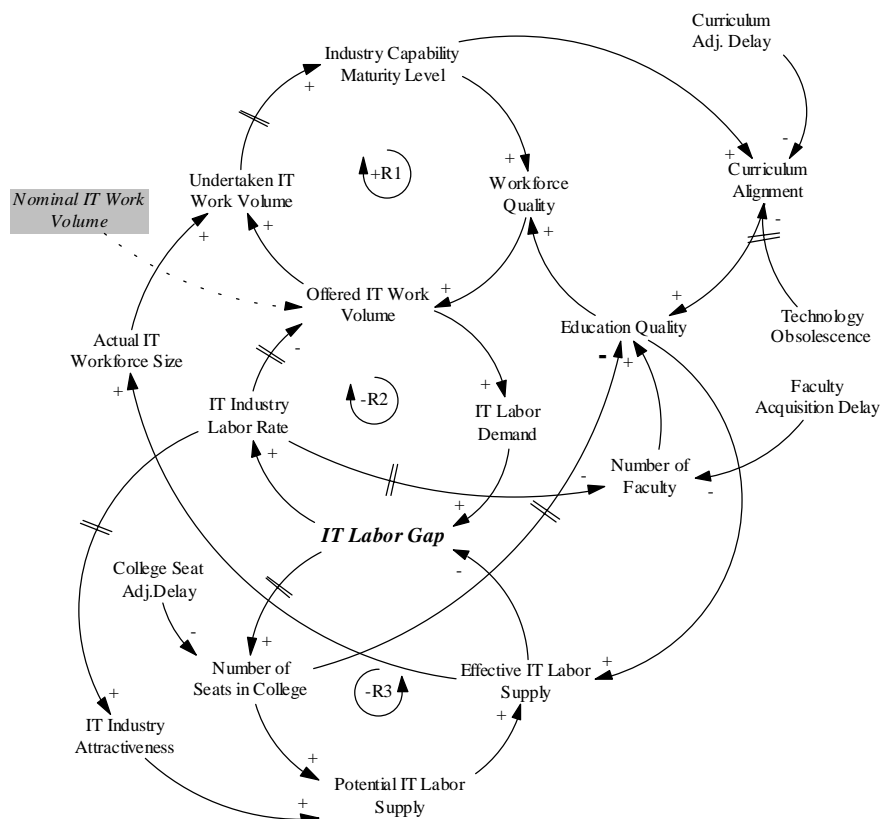
## 1. INTRODUCTION

The IT sector of several developing countries has realized significant economic gains from the global distribution of IT product development and service activities. India comes to mind as a prominent example, but there are many others such as Philippines, Russia and some east European countries (Bardhan and Kroll 2006; Kumar 2006; McDonald and Jacobs 2005). Moreover, even though IT sector growth may be resulting mostly from serving overseas customers, a byproduct has been the development of a healthy domestic market for IT products and services. Domestic organizations in these developing countries, in both the public and private sectors, are seeking to leverage information technology to improve their own products and processes, thereby improving their competitive positions or provide better public service. In other words, as a result of the global distribution of work (GDW), the IT sector has become not just another export business, but is being increasingly seen as an enabler of economic growth and national competitiveness in an era of globalization.

It is not surprising therefore, that these countries are anxious to sustain and even strengthen their IT sectors (Kraemer and Dedrick 2001). This has to be a multifaceted effort since there are many different aspects to the problem. For example, telecommunications infrastructure has to be reliable and its geographic coverage should be adequate. In this paper, we focus on one facet which stems from the fact that IT work is knowledge based (Rao 2004). While hardware, software and telecommunications are needed to execute the work, the distinctive production asset here is the qualified IT worker. Hence, maintaining an appropriate supply of qualified IT workers is absolutely central to sustaining and growing the IT sector (as it is for any other knowledge based sector such as biotechnology research and development) and continuing to benefit from GDW. The solution is also obvious – produce more well-trained graduates who can enter the workforce and satisfy the labor needs of the sector.

However, the process of ‘producing’ IT labor has certain characteristics that call for an understanding of not just equilibrium conditions but also the dynamics. First, increasing the aggregate number of seats available for students takes considerable time and is capital intensive. In developing countries, this may involve the burden of expanding basic infrastructure like roads, water and sanitation in addition to constructing the physical facilities for education. Moreover education capacity, once built, is not readily reduced. There is a critical shortage of qualified faculty and there are long delays associated with reducing that shortage. Curricula need modernization too. In short, the resources needed to process students through the education system take a long time to acquire and develop making

economies of scale. The sign of the relationship is represented by the positive polarity on the link, while the functional form will be captured in the underlying stock-flow version of the model that was mentioned in the previous section. The literature indicates that among the different factors that organizations consider in globally distributing IT work cost and quality of the vendor labor force rank among the most important ones (Levina and Ross 2003; Yen et al 2005). Hence there are two inbound links into *Offered IT Work Volume*, a positive one from *Workforce Quality* and a negative link from *IT Industry Labor Rate*. The link polarities are justified by the fact that higher workforce quality will lead to higher levels of offered work, while higher labor rates will lead to reduced levels of the same. Depending on the availability of trained workers, a developing country's IT sector may or may not be able to absorb all of the *Offered IT Work Volume*. Hence *Undertaken IT Work Volume* has two positive inbound causal links, from *Offered IT Work Volume* and *Actual IT Workforce Size*, respectively. The positive polarities of both links are self explanatory.



**Figure 1. Causal Loop Diagram of Sector level IT Labor Demand and Supply**

The literature on offshore project management is replete with studies highlighting the additional difficulties of executing globally distributed IT work (Oh, Gallivan and Kim 2006; Rao 2004). They include problems of control, communication, coordination, cultural conflicts and lack of business process knowledge among the IT workforce in the developing country. However, as more IT work is executed, learning occurs and execution improves (Chatzkel 2004; Murthy 2004). This explains the positive link from *Undertaken IT Work Volume* to *Industry Capability Maturity Level*. Since learning takes time, the link has a pair of vertical lines on it, signifying a delayed effect. This improvement in execution capability implies an improvement in workforce quality, represented by the positive link from *Industry Capability Maturity Level* to *Workforce Quality*, which in turn causes a positive link into *Offered IT Work Volume*. The second link coming in to *Workforce Quality* will be discussed shortly in the supply side narrative. The sequence of links just described generates a positive feedback loop labeled +R1 in Figure 1. As *IT Labor Demand* increases, so does the *IT Labor Gap*. Hence there is a positive link from the former to the latter. The mechanics of the demand side,

*Curriculum Alignment* and *Number of Faculty* to *Education Quality*, connect the preceding two mechanics together. Earlier in this section we had mentioned the impact of organizational learning on *Workforce Quality*. The positive link from *Education Quality* to *Workforce Quality* completes the second input reflecting the fact that *Workforce Quality* is a function of education quality as well as learning gained from executing IT work over time. Finally, the negative link from *Effective IT Labor Supply* to *IT Labor Gap* completes the interaction between the demand and supply sides forces at play.

In the foregoing narrative, the causal structure of Figure 1 has been presented by explaining the basis for individual links. It is also useful to note some of the larger macro structures resulting from these individual links. These feedback loops give a better idea of the broader mechanics in effect here. Earlier we had identified the positive (reinforcing) feedback loop labeled +R1. R1's inclination is to try and continuously increase the *Offered IT Work Volume* or in other words, to generate continued success for the IT sector of the developing economy. However, there are counteracting or negative feedback loops as well. Two are identified in Figure 1 as -R2 and -R3. The loop -R2 could be characterized as "succeeding one's way to stagnation", since it acts in a way that an increase in the labor gap results in reactions (salary increases) that stifle that increase. The loop -R3 is also a negative one, but its mechanics is one of sustenance. Here, if there is an increase in the labor gap, -R3 reacts by producing more graduates which corrects the labor gap. Of course, larger feedback loops can be identified in Figure 1. For instance the loop: *Undertaken IT Work Volume* → *Industry Capability Maturity Level* → *Curriculum Alignment* → *Education Quality* → *Effective IT Labor Supply* → *Actual IT Workforce Size* → *Undertaken IT Work Volume*, is a positive feedback loop which explains the mechanics by which curriculum improvements efforts benefits the IT sector. In closing, we point out one variable in Figure 1 that has been included solely to facilitate the execution of simulation runs in the next section. It is named *Nominal IT Work Volume*. The specifics of this variable will be discussed with the experimental results.

In this section, we have developed a causal model of the mechanics by which labor supply-demand imbalances occur in the IT sector of developing country. It is the collective effect of these multiple feedback loops that drive the *IT Labor Supply Gap*. While it is not hard to see the effect of one feedback loop, it is difficult to deduce the collective effect of multiple loops solely by qualitative reasoning with the CLD of Figure 1 alone. That is where the stock flow representation of this model becomes useful since it can be simulated to computationally determine the collective effect of the multiple causal relationships. We experiment with such a representation in the next section to analyze system behavior under different scenarios.

#### 4. EXPERIMENTAL RESULTS

The CLD of Figure 1 was converted to an equivalent stock-flow model using standard techniques of SD (Richardson 1996). Each stock variable results in a differential equation of the form  $d(\text{stock})/dt = \text{flow}$  or, alternatively,  $d(\text{stock})/dt = \text{function}(\text{auxiliary variables})$ . Once the conversion is complete, a CLD like that in Figure 1 generates a set of simultaneous differential equations, which can then be simulated to generate system behavior under different policies and conditions. In the remainder of this section, we present computational experiments that illustrate how the model can be used to help manage labor capacity, thereby supporting the IT sector in a developing country.

The first set of experiments illustrates the collective macro behavior generated by some key performance variables in the model under a baseline condition. This behavior can be examined for consistency and, taken together with explanations for the causal structure presented in the previous section, provides evidence of model validity for purposes of decision support. The unit of time for all the experimental runs referenced in this section is quarters, and the model was simulated for sixty quarters, or fifteen years, in each run. We consider this time granularity and simulation duration to be appropriate given the slow rates at which several of the variables under study here change in practice. It is also worth pointing out that in the discussion that follows, we will usually be more interested in analyzing patterns of behavior for relevant variables rather than their specific numerical values.

For the baseline case, *Faculty Adj. Delay* is set to 20 quarters on the assumption that it takes about five years for an individual to complete the education needed to become a qualified teacher. *College Seat Adj. Delay* is set to 30 implying that it takes, on average, about seven years to implement an expansion. This kind of delay is quite typical of developing countries. *Technology Obsolescence Delay* is set to 6 quarters. *Curriculum Adjustment Delay* is set to 6 quarters based on the observation that curriculum oriented industry-academia meetings occurring every two years or so at least in one developing country (India). For this baseline case, *Nominal IT Volume* is set to a value of 10 units for  $T=0$  to  $T=60$  creating a situation where the aggregate demand for IT work remains constant for the

the activity more quickly compared to governmental organizations. In other words, it is possible to change the delay associated with adjusting the number of college seats. While Figure 3 exhibits the expected transient behavior, the equilibrium value for industry labor rates is lower when the adjustment delay is low (line 3), compared to when it is high (line 1). So if the educational system responds faster to demand changes, it results in lower compensation levels. This may seem counterintuitive at first glance, but the reason is that a faster response means that excessive labor shortage does not occur and so the labor rates do not get a chance to increase as much as they otherwise might.

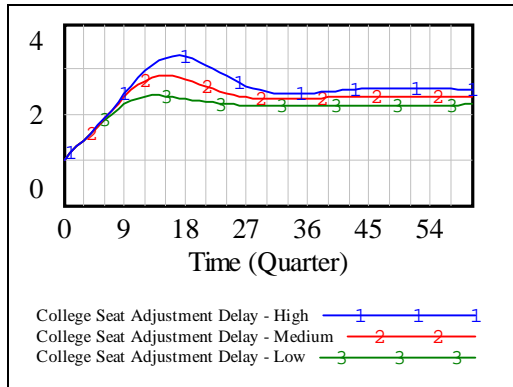


Figure 3. Sensitivity of IT Industry Labor Rate to College Seat Adjustment Delay

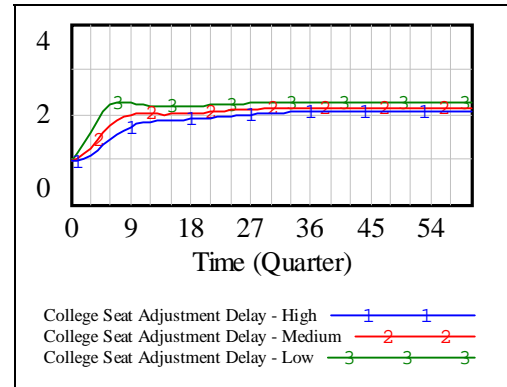


Figure 4. Sensitivity of Undertaken IT Work Volume to College Seat Adjustment Delay

Figure 4 shows the sensitivity of *Undertaken IT Work Volume* to three levels of *College Seat Adjustment Delay*. In contrast to Figure 3, notice that a faster response – i.e. low value of seat adjustment delay – results in a higher equilibrium value. Considering Figures 3 and 4 together, the implication for education capacity planning is that there is a tradeoff in choosing between a slower or faster response capability. The tradeoff is between the number of people employed by the sector and the average compensation levels enjoyed by those employees. Turning now to the impact of education quality, Figures 5 and 6 show the sensitivity of *IT Industry Labor Rate* and *Undertaken IT Work Volume* to *Curriculum Adjustment Delay*, respectively.

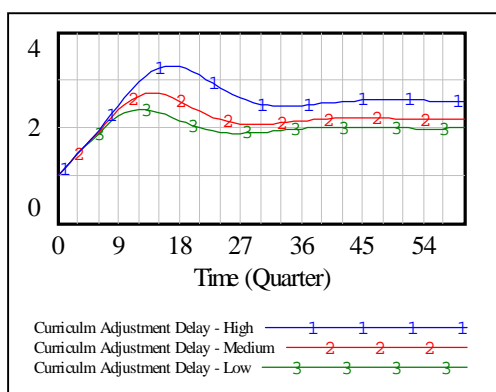


Figure 5. Sensitivity of IT Industry Labor Rate to Curriculum Adjustment Delay.

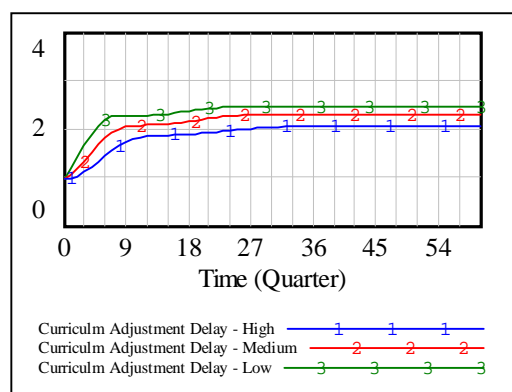


Figure 6. Sensitivity of Undertaken IT Work Volume to Curriculum Adjustment Delay

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