Evaluation and Program Planning 33 (2010) 487–497

Contents lists available at ScienceDirect

Evaluation and Program Planning

journal homepage: www.elsevier.com/locate/evalprogplan

Evaluating a national science and technology program using the human capital and relational asset perspectives

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ARTICLE INFO

Article history:
Received 31 August 2009
Received in revised form 28 January 2010
Accepted 31 January 2010

ABSTRACT

The purpose of this research is to evaluate the performance of the National Science and Technology Program (NSTP) by targeting the Taiwan National Telecommunication Program (NTP) initiated in 1998. The Taiwan telecommunications industry has prospered, currently occupying key positions in global markets even though NTP seldom contributes positively to patent citation performance. Hence, the authors of this study investigate the qualitative perspective of intellectual capital rather than quantitative technological indices. The current study focuses on both human capital and relational assets through surveys of 53 principal investigators of NTP projects and 63 industrial R&D managers of telecommunications corporations in the Taiwan market. Results show that NSTP member quality and the flow of employment are good indicators of human capital and that both perform better than the middle value in the case of Taiwan NTP. In addition, we find that industrial participants are more likely to share R&D resources than other academic researchers with higher intention of co-publishing, co-funding, and sharing equipments and facilities. The industrial NTP participants also have higher expectations regarding achieving advanced technology breakthroughs in contrast to non-NTP industrial interviewees. Moreover, industrial participants with greater industry–university cooperation intensity indeed obtain a particular advantage, that is, greater knowledge acquisition from other fields related to the effect of knowledge spillovers through the particular NSTP linkage. Accordingly, from the perspectives of human capital and relational assets, the authors conclude by articulating the importance of absorptive capacity resulting from good human capital and knowledge spillover contributed by relational assets within governmental technology policy and NSTP programming.

1. Introduction

In the ever-changing 21st century, most industrialized countries allocate resources in pursuit of frontier technologies in order to retain their economic leadership in the face of global competition. Taiwan, the Silicon Island, has also invested large sums in science and technology since 1998, through the initiation of nine national science and technology programs (henceforth abbreviated as NSTPs) in the diverse areas of telecommunications, digital archives, digital learning, hazards mitigation, nanotechnology, biotechnology and pharmaceuticals, agricultural biotechnology, genomic medicine, and system on chip (NSC, 2007a). Specifically, the NT$24 billion (about US$0.73 billion) budget of the Taiwan National Telecommunication Program (henceforth abbreviated as NTP) accounts for 22.2% of the total NT$108 billion (about US$3.3 billion) in NSTP investments. Fig. 1 shows the NTP organizational chart, which represents the funding flows mainly coming from four governmental ministries and one government-based telecom corporation; the supervision direction is coordinated by a special program committee. In reality, most research projects are organized and conducted in the universities and several national-level R&D institutes. Other NSTP programs were also orchestrated by similar structures. However, in the case of NTP outcome, few Taiwan telecom vendors have managed to dominate the global telecommunications industry for an extended period outside of Nokia (Finland), Ericsson (Sweden), Qualcomm and Motorola (USA), DoCoMo (Japan), and Samsung (Korea). Although the number of patents sponsored by NTP through 1998–2006 totalled to 925 (NSC, 2007b), only 225 of these patents were closely related to telecommunications technology (i.e., those of the H04 group by the USPTO classification scheme), implying a mere 27.6% of the total number of NTP patents. Even worse, the patent impact of NTP has generally been low. According to the patent impact identification method of Thomas and Breitzman (2006), hot

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doi:10.1016/j.evalprogplan.2010.01.003

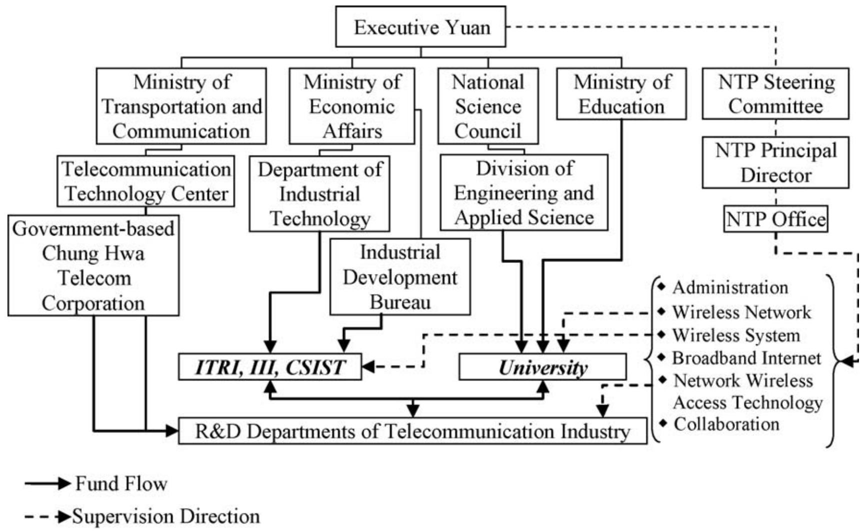

Fig. 1. Taiwan NTP organizational chart and funding–supervision relationship.

patents with high impacts usually have a minimum of 10 recent citations. There have only been 12 such "hot" NTP patents, mostly produced by the Industrial Technology Research Institute (ITRI) and the Institute for Information Industry (III) of Taiwan, both of which are Taiwan government-sponsored research organizations. In fact, over 73% of NTP participants had low-impact patents with zero citations. However, the real performance of NTP should not be solely evaluated based on the perspective of number of patents issued or hot patents, because Taiwan ICT manufacturers continue to occupy important positions in the global marketplace. For example, Taiwan is the largest wafer foundry, CD, DVD, and Mask ROM production center, and second largest in terms of IC design, WLAN, xDSL CPE, Cable CPE, and routers (NSC, 2007a). Therefore, a robust measurement of NTP performance should include other dimensions such as the quality of human resources trained at NTP and the innovation and entrepreneurship resulting from the relational assets within the industry-university cooperation network. The purpose of this paper is to discover the real value of the NSTPs by constructing a non-patent evaluation framework associated with the case of NTP.

2. Evaluation framework

Lepori (2006) points out that the national R&D budget for NSTPs often plays the role of input indicator for future science and technology performance. Hence, the Organization for Economic Cooperation Development developed a Frascati Manual that clearly identifies several key R&D sources (OECD, 2002). However, verifying the expenditure flow, especially the flows to research personnel who actually embody the output knowledge, is even more vital than focusing on R&D input (Stewart, 1997). If the national R&D input flows mostly to education, training, instruction, and mentoring of researchers, then growth in the capability for technology innovation and exploitation will be expected. Stewart (1997) argues that R&D input in research personnel as an intellectual investment will create the following three types of future competitive advantage: embodied human capital, internal structural assets, and external customer assets. Bontis (1998) further specifies that the third type of competitive advantage is both the most sustainable and the most difficult to imitate, followed by embodied human capital. Therefore, these two types of competitive advantages will be the focus of our assessment of the NSTP evaluation framework.

2.1. Perspective of human capital

Lanzi (2007) measured the quality of research human capital based on the three elements of basic skill, professional capability, and continuous learning abilities. Wu (2006) also emphasizes that the real quality of research personnel is often reflected in job salary, job status, and problem solving capability. It is important to consider the "absorptive capability" of human resources in order to be better equipped to acquire knowledge and raise the possibility of invention in the future (Cohen & Levinthal, 1990). Kundu and Kumar (2006) claim that special industrial training and development programs actually help employees achieve corporate goals and personal career objectives as well as improve their productivity. Mann and Robertson (2006) further suggest that training evaluation programs should not focus only on training satisfaction and planned behavior but also on the enhancement of employees' learning capabilities and organizational contribution after training.

In addition, the notion of perceived high quality of human capital also requires the appreciation of demanding employers (Cozzens, 1997). A correct match that does not waste the talent pool can only perform to the standards of the actual quality of human capital. Therefore, Luwel (2005) finds that the flow of talent is a good indication of knowledge diffusion and industrial development resulting from national programs. It is important for most newly industrialized or less-developed countries to focus their limited national resources on diffusion-oriented technology policy for expertise training and knowledge diffusion widely (Chiang, 1990). According to Callon, Larédo, and Mustar (1997), intermediaries who can transfer, translate, and disseminate information to bridge the poles of science, technology, and market are also required throughout in the value exploitation process of innovation. Further, Wu (2006) emphasizes that the appropriate flow of talent toward emerging industries can only contribute to one of the national program objectives—industrial enhancement and upgrading.

2.2. Perspective of relational assets

Beyond measuring the quality and flow of human capital from NSTP, the relational asset that Bontis (1998) specifies as the most important advantage in terms of the external customer asset is also a useful indicator of NSTP research personnel performance. Dalpe (1993) and Georghiou (1998) both propose that the number of