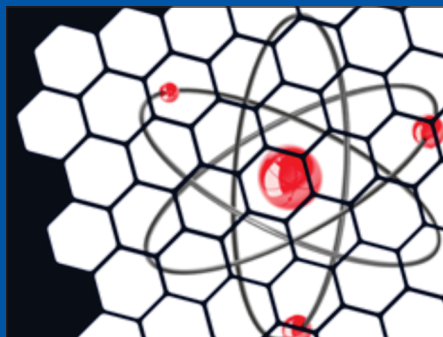




सत्यमेव जयते

Government of India  
Ministry of Communications  
Department of Telecommunications

# Quantum Communication Technologies & Products 2023



**Inter-Ministerial Committee report on Quantum Communication**

(Disclaimer: TRL levels mentioned are as declared by the companies/Institutes.)

and the number of children in the household. The model is estimated using the following equation:

$$\ln(\text{hours worked}) = \beta_0 + \beta_1 \text{gender} + \beta_2 \text{education} + \beta_3 \text{experience} + \beta_4 \text{children} + \beta_5 \text{household} + \epsilon \quad (1)$$

where  $\ln(\text{hours worked})$  is the natural logarithm of the number of hours worked per week,  $\beta_0$  is the intercept,  $\beta_1$  is the coefficient on gender,  $\beta_2$  is the coefficient on education,  $\beta_3$  is the coefficient on experience,  $\beta_4$  is the coefficient on children,  $\beta_5$  is the coefficient on household, and  $\epsilon$  is the error term.

The dependent variable is the natural logarithm of the number of hours worked per week. The independent variables are gender, education, experience, children, and household.

The coefficient on gender is expected to be positive, indicating that men work more hours than women. The coefficient on education is expected to be positive, indicating that more educated workers work more hours. The coefficient on experience is expected to be positive, indicating that more experienced workers work more hours. The coefficient on children is expected to be negative, indicating that workers with children work fewer hours. The coefficient on household is expected to be positive, indicating that workers in larger households work more hours.

The model is estimated using ordinary least squares (OLS). The results are reported in Table 1. The dependent variable is the natural logarithm of the number of hours worked per week. The independent variables are gender, education, experience, children, and household.

The coefficient on gender is 0.15, which is statistically significant at the 1% level. This indicates that men work 15% more hours than women, holding all other variables constant. The coefficient on education is 0.08, which is statistically significant at the 1% level. This indicates that workers with a college degree work 8% more hours than workers with a high school diploma, holding all other variables constant.

The coefficient on experience is 0.02, which is statistically significant at the 1% level. This indicates that workers with 10 years of experience work 2% more hours than workers with 5 years of experience, holding all other variables constant. The coefficient on children is -0.05, which is statistically significant at the 1% level. This indicates that workers with children work 5% fewer hours than workers without children, holding all other variables constant.

The coefficient on household is 0.03, which is statistically significant at the 1% level. This indicates that workers in a household of size 4 work 3% more hours than workers in a household of size 2, holding all other variables constant.

The adjusted  $R^2$  is 0.12, indicating that the model explains 12% of the variation in the number of hours worked per week. The F-statistic is 12.5, which is statistically significant at the 1% level. This indicates that the model is a good fit for the data.

The results of the OLS regression are consistent with the theoretical predictions. Men work more hours than women, more educated workers work more hours, more experienced workers work more hours, workers with children work fewer hours, and workers in larger households work more hours.

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## 1. Entangled Photon Source

Description	Company	TRL	Pilots
Entangled photon source is the most important resource for quantum ,generates more than 100 k entangled photon pairs per second at 810 nm science and technology	Qutess Lab	8	PRL
<b>ACADEMIA</b>			
PRL (Shri R P Singh) TRL 6	IIT Jodhapur(Prof. V Narayanan)	TRL 4	
PRL (Dr. Goutam K Samanta) TRL 9	IIT Delhi(Dr Joyee Ghosh:Integrated Source)	TRL 4	
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 9			

## 2. Single photon sources

Description	Company	TRL	Pilots
SPS at telecom wavelength			
<b>ACADEMIA</b>			
IIT Delhi(Prof. Bhaskar Kanseri : Heralded ) TRL 4			
RRI-QUIC Lab(Prof Urbasi Sinha:QIP Based) TRL 9			
PRL (Dr. Goutam K Samanta) TRL 9			

### 3. Single-Photon Detector

Description	Company	TRL	Pilots
<p>A gated avalanche single photon detector using InGaAs APD. The gating pulses are supplied by FPGA and photon pulses are counted by FPGA. The operational wavelength is C-band (1550 nm) with counting rate of 1 to 10 MHz. The dark count rate of the SPD modules is less than 1E-5.</p>			
<b>ACADEMIA</b>			
IIT Kanpur(Dr. K. Pradeep Kumar) TRL 5			
IISC(Prof Kaushik Majumdar) TRL 4			

#### 4. Single photon detector based on High temperature Superconductors (HTS)

Description	Company	TRL	Pilots
The technology is based on High temperature Superconductors (HTS) as opposed to the currently-available standard low temperature superconductivity rendering it indispensable for cost-effective and efficient Quantum Information Processing. High temperature superconductors use Liquid Nitrogen for cooling, unlike the conventional superconductors based on liquid helium.	SuperQ	5	Trial to be completed with Academic Partners in Q1 2023





## 5. Single Photon Detector based on Low-Temperature Superconductors

Description	Company	TRL	Pilots
The technology is based on Low temperature Superconductors (LTS) rendering it indispensable for Quantum Information Processing. The chipset is developed by SuperQ.	SuperQ	6	

## 6. Quantum Clock

Description	Company	TRL	Pilots
Neutral Sr atoms are trapped in an optical lattice and single ytterbium-ion trapped in a Paul trap to reach a fractional accuracy of a few parts in $10^{18}$ .			
<b>ACADEMIA</b>			
IISER Pune(Prof Umakant D Rapol)			
Inter-University Center for Astronomy and Astrophysics Pune( Prof Subhadeep De)			

## 7. Quantum Chipset

Description	Company	TRL	Pilots
QpiAI-Quantum chipset is 3 chip solution consisting of Classical compute chip based on silicon photonics as universal optimizer chip called Trion. We have 128 qubit control chip that can control any types of Qubits including superconductor, Semiconductor and trapped Ions. We have 3 chip which is spin qubits based on semiconductors and superconducting qubits	QpiAI	2	



8. Quantum Random Number Generator- Hardware based RNG

Description	Company	TRL	Pilots
Generates 100% random numbers using quantum photonic source Entropy is of the highest level possible	QUNU Lab (Tropos)	9	BEL, WESEE, Strategic Agencies
	Scytale	7	Strategic Agencies
	TAQBIT	7 to 8	NA
	Qutess Lab	6	PRL
	C-DAC	2	

**ACADEMIA**

SETS (Dr Natarajan): TRL 8

JIIT(Prof. Anirban Pathak)

IISC (Prof C M Chandrashekar): TRL 7

RRI-QUIC Lab(Prof Urbasi Sinha) TRL 6

IIT Kanpur(Dr. K. Pradeep Kumar) TRL 6

PRL (Dr. Goutam K Samanta) TRL 4



## 9. Quantum Random Number Generator- Cloud based RNG

Description	Company	TRL	Pilots
Generates 100% random numbers using quantum photonic source Entropy is of the highest level possible	QUNU Lab (Qosmos)	9	BEL, WESEE, Strategic Agencies

### 10. Integrated quantum control & readout system

Description	Company	TRL	Pilots
It is a scalable and modular control stack for quantum computing and quantum key distribution (QKD) systems.	QpiAI (QpiSense)	4	

## 11. Quantum Key Distribution Solution

Description	Company	TRL	Pilots
QKD securely distributes keys which can be used of encryption purposes by an application entity. This mitigates the threat posed by Quantum Computers to present day mechanism of encrypting data application entity.	C-DOT	9	Trial and demonstration carried out for strategic agency (110 Kms lab, 50 Km in Field)
This mitigates the threat posed by Quantum Computers to present day mechanism of encrypting data.	QUNU Lab (Armos)	9	BEL, WESEE, Strategic Agencies and Others (150Kms. Using single hop QKD)
	TAQBIT	7-8	
	Qutes Lab	7	PRL & SAC
	CDAC	2	Free Space Based



**ACADEMIA**

JIIT (Prof. Anirban Pathak, QKD-Cow set up)

IIT Delhi (Prof. Bhaskar Kanseri, QKD based on Polarization) TRL 2

IIT Delhi(Prof. Bhaskar Kanseri, QKD based on DPS: Developed) TRL 6 -7

RRI-QUIC Lab (Prof Urbasi Sinha, Integrated photonics based QKD ) TRL 2 to TRL 3

IIT Delhi (Prof. Bhaskar Kanseri, QKD based on Entanglement) TRL 2

IISC(Dr. Varun Raghunathan:Measure Based QKD) TRL 2-4

IIT Kanpur(Dr. K. Pradeep Kumar: Frequency Coded QKD System) TRL 6

PRL (Dr. Goutam K Samanta QKD based on Entanglement) TRL 9

RRI-QUIC Lab (Prof Urbasi Sinha, Free Space based QKD) TRL 7



## 12. Free space QKD with entangled photons

Description	Company	TRL	Pilots
implemented BBM92 QKD protocol with secure key rate of around 2 kb/s for atmospheric channel	CDAC Corp R&D	2	
<b>ACADEMIA</b>			
PRL(Shri R P Singh) TRL 9			
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 9			
PRL (Dr. Goutam K Samanta) TRL 9			
IIT Delhi(IIT Delhi(Prof. Bhaskar Kanseri, entanglement based Polarization :Undeveloped) TRL 2			

### 13. Key Distillation Engine for QKD protocol

Description	Company	TRL	Pilots
Hardware (FPGA) device for robust authentication and post-processing modules with 4 Mbps throughput. Integrated encryption module with 10GB/s.			
<b>ACADEMIA</b>			
SETS (Dr Natarajan): TRL 8			

## 14. Novel QKD protocols with security proof

Description	Company	TRL	Pilots
For security of communications			
<b>ACADEMIA</b>			
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 8			

### 15. Trusted Relay Node

Description	Company	TRL	Pilots
A trusted node consists of a quantum receiver linked to a quantum transmitter, which is housed in a secure boundary, designed to prevent tampering	QUNU Lab	9	BEL, WESEE, Strategic Agencies
<b>ACADEMIA</b>			
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 1			

## 16. Hub & Spoke QKD

Description	Company	TRL	Pilots
Connects One bob with 5 Alices with each Bob to Alice link up to 100Kms.	QUNU Lab	8	BEL, WESEE, Strategic Agencies
	C-DAC Bangalore; SETS,IITM	4	

## 17. Long Distance Teleportation

Description	Company	TRL	Pilots
Fiber based teleportation over >100 kms.			
<b>ACADEMIA</b>			
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 1			

## 18. Quantum State Interferography

Description	Company	TRL	Pilots
New interferometry based tool. Tremendous scaling advantage over commonly used methods.			
<b>ACADEMIA</b>			
RRI-QUIC Lab(Prof Urbasi Sinha: prototype demonstration has been achieved) TRL 3			

## 19. QSIM

Description	Company	TRL	Pilots
The QSim offers a robust QC Simulator integrated with a GUI based workbench that allows users to create quantum circuits and simulate on high performance super computers.	CDAC	9	Qsim v1.0 is live @ qctoolkit.in

# QSim: Quantum Computer Simulator Toolkit

Playground for anyone passionate to learn or experiment in quantum computing, be it students, faculty or researchers.

[Launch Workbench](#)



## 20. Post Quantum Cryptography Encryptor

Description	Company	TRL	Pilots
PQC is envisaged to replace the current key-exchange protocols (used in IPSec, TLS etc. communication security protocols) that are under-threat from upcoming Quantum Computers.	C-DOT	9	Trial and demonstration carried out for a Strategic agency
	QUNU Lab (Hodos)	9	
	Secure Machine	8	



## 21. Quantum Enabled NextGen Enterprise Messaging Platform

Description	Company	TRL	Pilots
NextGen Enterprise Messaging platform for Sensitive Communications using Quantum Technology. The platform works on the principle of Consent based Messaging and has Data Loss Prevention capabilities within it.	Arishti CyberTech Private Limited (MessageMe™)	9	Ongoing within BFSI and Local Police Departments
	QUNU Lab	9	



## 22. Quantum Video Conferencing

Description	Company	TRL	Pilots
Secure Video Conference	Scytale	7	Armed Forces

### 23. Quantum Network Simulator

Description	Company	TRL	Pilots
Simulation of the realistic situations of Quantum Internet, with novel routing protocols and shortcuts in the quantum networking.	QpiAI	7	Infosys
	CDAC BLR	2	
<b>ACADEMIA</b>			
RRI-QUIC Lab(Prof Urbasi Sinha) TRL 7			



## 24. Quantum Solutions in different vertical sector

Description	Company	TRL	Pilots
Simulator for specific vertical sector	Enterprise QpiAI Pro	9	
	QpiAI Explorer	9	
	QpiAI Logistics	9	
	QpiAI Finace	9	
	QpiAI Pharma	8	

### QpiAI Pro

#### AutoML & MLOps platform.

An enterprise AutoML & MLOps platform catalyzing AI based digital transformation & enabling cross-domain collaboration. Through patented technology, QpiAI Pro streamlines the process to create & deploy advanced AI solutions, transforming data warehouses into repositories of wisdom.



### QpiAI Explorer

#### Fastest way to learn and explore AI & Quantum.

QpiAI Explorer is the fastest way to learn, to train & to make play with Quantum Computing in cloud as well as in the IBM Quantum network. It enables end-to-end program delivery in 15-20 mins. Integration.



### QpiAI Logistics

#### Classical & quantum-inspired optimization tools.

QpiAI Logistics is a suite of classical & quantum-inspired optimization tools to solve logistics & supply chain optimization problems.



### QpiDHDE

#### Collaborative healthcare innovation platform.

QpiDHDE is a collaborative healthcare innovation platform formed by the hybrid composition of classical & quantum. It drives innovation in healthcare, solves most intractable problem while ensuring privacy & security of healthcare data.



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