An Econometric Model for Forecasting the ICT*) Business Markets
– A Simultaneous Multi-Equation Modelling Approach

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The ICT markets underwent a profound metamorphosis and continue to be under a high pressure. The main factors underlying this change are (a) the deregulation and liberalization of the European telecommunications markets, (b) the explosion of new services and technology, (c) the increasing and aggressive competition between incumbent Telcos, new operators and also the IT integrators, and (d) the convergence of IT and telecommunications. These factors lead to increasing complexity and difficulties in modelling and forecasting products and services on business markets. These new constraints and customers' and players' behaviours were not adequately integrated in the 'traditional' modelling (ie. multiple regression, time series with transfer function, diffusion models, ...) and led to inconsistent and inaccurate forecasts, with corresponding shifts in supply and demand. Most attempts to model the Telecoms and ICT markets have concentrated on the demand side. Only a few modelling studies have been carried out on both demand and supply. Of these, the majority were at a highly aggregated level. In this paper we present: (a) a global overview of the ICT markets, (b) a description of the forecasting methodology we suggest, based on a system of simultaneous multiple regression equations, establishing multiple linkages between, on the one hand, the demand for a variety of ICT products and services and, on the other, the supply and the economic, regulatory and technology environment.

Warning: The opinion and analysis expressed in the present paper engage solely the author.

1 Introduction

The increasing convergence between Telecommunications and Information Technology (IT) is probably the most important factor of the huge change in the industry. This is driven by the rivalry of IT providers and telecommunications operators. In particular, telecommunications operators are progressively entering formerly exclusive IT company markets, eg. helpdesk, data centers and business applications. Simultaneously, IT providers are encroaching on activity that is usually 'reserved' for telecommunications operators. Additionally, former telecommunications operators (eg. Orange Business Services, BT Global Services, T-Systems, Telstra, …) are offering IT and telecommunications services by making strong bids to enter IT service delivery markets. Conversely, IT companies such as Atos, EDS and IBM Global Services are offering services which overlap with the core domains of telecommunications operators, such as managed services, management of data centers, hosted applications and unified communications.

The convergence of IT and Telecommunications has created more complex behaviours in the business markets. Small and Medium-sized Enterprises (SMEs) and Multinational Corporations (MNCs) and Large Enterprises (LEs) are expecting new offerings to coincide with the emergence of new needs owing to their growth and globalization. These kinds of companies need more integrated solutions for security, for mobility, for hosting, for new added-value services, for outsourcing, for VoIP and for many other needs. All this has led to the decline of 'traditional' products and services such as access lines, fixed voice, ISDN and data, and we have seen substitution effects between many products and services.

Demand for traffic and capacity, revenue and market share were estimated on the basis of multiple regression models (with a single equation) associated with assumptions about socio-economic variables. In the past decade, however, the links between three factors – the demand for IT and Telecom services, the economic and political environment (ie. in macroeconomic factors, deregulation and liberalization, innovation, globalization etc) and supply (investments in technology and new solutions, consulting, outsourcing ...) – have become visible. To handle this complexity in the forecasting models it became necessary to find out an alternative approach. The aim, therefore, is to present and run a simple forecasting model based on a multi-equations structure.

2 The ICT Business Market: Definition and Scope

The definition of ICT used here may be different from that used elsewhere. The OECD and EU definitions of ICT include the following categories: telecommunications; consumer electronics; computers

*) *ICT: Information and Communications Technology*

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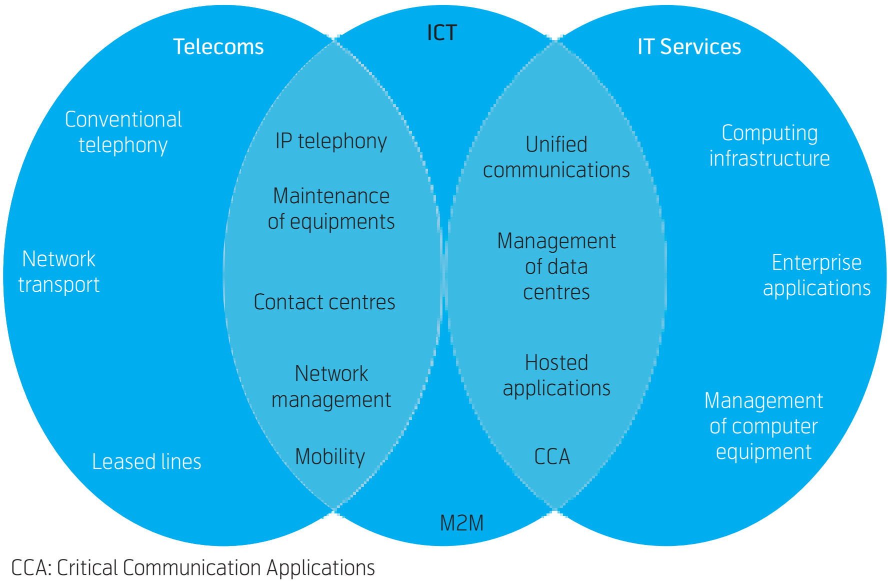

Figure 1 ICT scope

and office machinery; measurement and control instruments; and equipment and electronic components.

Figure 1 presents the scope of ICT (Information Communication Technology) as agreed in a large part of the industry. Our work is based on this scope. A detailed description of the ICT's variables is provided in the next section.

3 Model Description and Specification

3.1 Model Description

Figure 2 summarizes the overall design of the core ICT model. There are three main groups of variables; a) supply variables, b) demand variables, and c) environmental variables. This model is applied to the French ICT market.

a) Supply Variables

The supply variables include the product prices of telecommunications operators and IT providers. The price variables are expressed as average revenue per user (ARPU) or average price per staff member (Euro/staff). Supply variables also include network capacity, and dedicated SMEs, MNCs and LEs access. The capacity variables represent the ability of providers to meet customer needs in terms of bandwidth (especially broadband) and traffic (eg. Voice over IP – VoIP). Also included are bundles and a service catalogue that represent the negotiated product prices. For instance, some prices in the product catalogue are 20 to 30 % below publicly listed prices.

b) Demand Variables

Demand variables are categorized by:

1 Data services which include security software, network devices, Wide Area Network (WAN) and Internet access, managed services and Remote Access Services (RAS);

2 Voice services which are comprised of PBX (Private Branch Exchange) and IPBX (Internet Private Branch Exchange) and fixed voice;

3 Mobile data services which include Internet and mobile messaging;

4 Mobile voice services which include mobile voice;

5 Communication services contain MNCs, SMEs and LEs collaborative application support, videoconferencing and messaging;

6 Applicative solutions and services concern new services such as business intelligence and machine-to-machine transmission;

7 Desktop management services which include infrastructure software (Citrix) and workstation (PDA – Personal Digital Assistant – and laptop) services; and

8 IT Infrastructure services which include servers, LAN (Local Area Network) and WAN (Wide Area Network).

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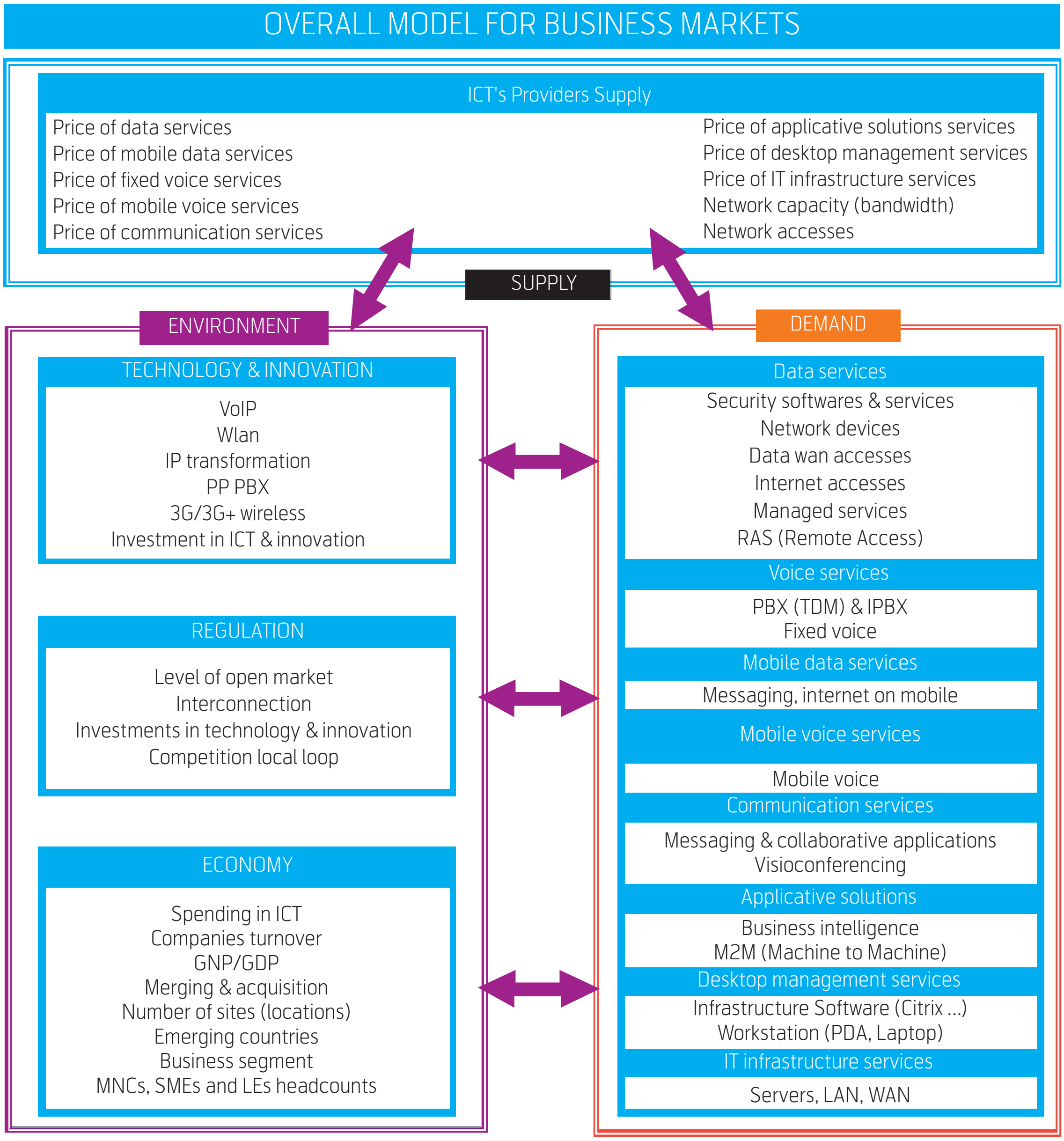

Figure 2 The overall model description

c) Environmental Variables
Environment variables are:

1 Technology and innovation variables represent the availability and intensity of new service deployment such as VoIP, IPBX and 3G (3rd Generation that allows improved roaming). Also included is ICT investment by manufacturers and SMEs, MNCs and LEs;

2 Regulation variables relate to policy levers, market openness (which has a significant impact on ICT markets), connection between rules, and fees and obligations, ie. the obligation to invest in new technology and innovation, and universal service obligations; and

3 Economy variables concern GNP (Gross National Product), GDP (Gross Domestic Product), SMEs, MNCs and LEs headcounts (employees), company turnover and company locations (number of sites). Also included are SMEs, MNCs and LEs IT services and telecommunication operator expenditures (eg. access fees and licenses).

Table 1 lists the principal explanatory variables identified by category for ICT business markets. As all variables interact several alternative model specifications are examined. Data sources, variable descriptions and construction are described in the Appendix. The following aspects are emphasized below:

1 Dummy variables are used to represent qualitative effects, ie. market openness, and the state of MNCs, SMEs and LEs IP transformation. For

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Variables	Variables code	Quarterly data (1)
1 – ICTs Providers Supply		MEuro
Price of data services	P_D	Euro
Price of mobile data services	P_MD	Euro
Price of fixed voice services	P_FV	Euro
Price of mobile voice services	P_MV	Euro
Price of communication services	P_COM	Euro
Price of applicative solutions services	P_APL	Euro
Price of desktop management services	P_DK	Euro
Price of IT infrastructure services	P_ITINF	Euro
Network capacity and broadband	NC	Mbits
Bundles and catalogue of services	BUNCAT	%
Network accesses	NA	Thousands
2 – Technology & Innovation		
VoIP	VoIP	Dummy variable
WLAN	WLAN	Dummy variable
IP transformation	iPTRANS	Dummy variable
IP PBX	iPBX	Dummy variable
3G/3G+ wireless	3G_WIRS	Dummy variable
3 – Regulation		
Level of open market	OPEN_MKT	1 to 5
Interconnection	INX	Dummy variable
Investments in ICTs & innovation	INV	MEuro
Competition local loop	COM_LLOOP	Dummy variable
4 – Economy and business		
Spending in ICTs	SPEN	MEuro
Customers turnover	TURNOV	MEuro
GNP/GDP	GDP	MEuro
Merging & acquisition	MERGE	MEuro
Number of sites	SITES	Units
Business segment	BUS_SEG	Dummy variable
Competition in NRS services	COMPNRS	%
MNCs, SMEs and LEs headcount (staffing)	EMP	Thousands
5 – Demand of IT/telecom services		
5.1 – Data services	*DAT_SER*	*MEuro*
Security softwares & services		MEuro
Network devices		MEuro
Data wan accesses		MEuro
Internet access		MEuro
Managed services		MEuro
RAS (Remote Access)		MEuro
5.2 – Voice services	*V-SER*	*MEuro*
PBX (TDM) & IPBX		MEuro
Fixed voice		MEuro
5.3 – Mobile data services	*MD_SER*	*MEuro*
Workstation (PDA, laptop)		MEuro
5.4 – Mobile voice services	*MV_SER*	*MEuro*
Mobile voice		MEuro
5.5 – Communication services	*COM_SER*	*MEuro*
Messaging & collaborative applications		MEuro
Visioconferencing		MEuro
5.6 – Applicative solutions	*APL_SER*	*MEuro*
Business intelligence		MEuro
M2M (machine to machine)		MEuro
5.7 – Desktop management services	*DESK_SER*	*MEuro*
Infrastructure software (Citrix ...)		MEuro
Workstation (PDA, laptop)		MEuro
5.8 – IT infrastructure services	*IT_SER*	*MEuro*
Servers, LAN, WAN		MEuro

(1): As some statistics were based on USD, the exchange rate is provided by IMF source

Table 1 Detailed description of variables and units

instance, market openness is scaled on a 5-point Likert scale indicating low through complete market openness;

2 Data series for many new and innovative services (eg. VoIP and 3G for mobile) are necessarily short; and

3 Secondary data sources commonly report data as annual observations. Accordingly, these data are converted to quarterly observations to enable consistent model estimation.

3.2 Model Specification and Identification

Forecasting ICT demand and supply in convergent telecommunications and IT markets that are experiencing much innovation, must consider cross-elastic impacts. Single-equation estimation is unable to include interaction among sub-markets that are characterized by new technology and services for which there is a paucity of historical data (eg. IPBX, 3G, ADSL+ and VoIP) (Rao and Angelov 2005). An alternative approach is to apply a multi-equation framework to the ICT market (Loomis and Swann, 2004). For this system, single equation Ordinary Least Squares (OLS) estimation is biased when arguments are endogenous (Fisher 1966; Fernández 1981; Brown 1983; Amemiya 1986). OLS parameter estimates in a structural simultaneous equation system are biased and inconsistent because of non-zero correlations among the random error term and right-hand side endogenous variables (Gorobets, 2005). Consistent parameter estimates are obtainable from Indirect Least Squares (ILS), Instrumental Variable (IV), Two-Stage Least Squares (2SLS) or Three-Stage Least Squares (3SLS) routines. In this study, we used Syslin-3SLS and Model-3SLS in SAS software.

3.3 Software used for Estimation

Syslin-3SLS and *Model-3SLS* in SAS software provide robust and consistent 3SLS – Three Stage Least Squares estimations. Syslin-3SLS should be used for linear models and Model-3SLS should be used for nonlinear and linear equations.

To sum up, both procedures calculate 2SLS estimates of identified equations; get errors of SF (structural form) equations; use these to get contemporaneous var-cov matrix of SF errors; apply GLS to the large equation of all the identified equations of the system.

In terms of properties, 3SLS is generally consistent and more efficient than 2SLS asymptotically. If the disturbances in the different SF equations are uncorrelated (var-cov matrix is diagonal) 3SLS reduces to 2SLS. 3SLS is at least as efficient as any other estimator which uses the same amount of information. It is also asymptotically equivalent to 2SLS.

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These procedures should be used when (a) there is no misspecification, (b) there is error correlation in different SF equations, and (c) for over-identified equations.

Both procedures are identical to 2SLS if (a) contemporaneous variance-covariance matrix is diagonal, (b) all equations in the system are just-identified. If 2SLS and 3SLS estimates are similar, this is evidence that 3SLS is done properly.

3.4 Data Set

Models are applied on the French ICT market. The dataset includes 33 quarterly observations – Q1.2000 to Q1.2008 – (detailed information on the dataset is available in Appendix 1, page 105). As the majority of *demand* and *supply variables* are originally based on annual periodicity, they were converted from annual to quarterly periodicity using these both methods:

a Seasonal coefficients from other European markets (close to French market) were applied to the data set allowing conversion of annual data to quarterly data;

b The second methodology is based on the Chow-Lin procedure for quarterly interpolation of annual data (Chow, G and Lin, A L, 1971) and (Pavía Miralles, J M, Vila Lladosa, L-E et al, 2003).

For *environment variables*, the majority are originally based on quarterly periodicity.

3.5 Model Specification

Model 1

ICT product *j* supply function specifications are of the form:

$$\ln y^s_{jt} = a_s + \beta_s \ln INV_{t-1} + \sum_j \gamma_{sj} \ln P_{jt} + \\ + \sum_j \delta_{sj} \ln y^d_{jt} + \varepsilon_s \ln NA_t + \xi_s \ln NC_{t-1} + u_t \quad (1.1)$$

where:

- y^s_{jt} is product *j* supply
- INV_{t-1} is ICT and technology investment
- P_{jt} is product *j* price
- y^d_{jt} is product *j* demand
- NA_t is network accesses
- NC_{t-1} is network capacity
- u_t is a random error term
- β_s is the ICT and technology investment supply elasticity
- γ_{sj} is the own-price elasticity of supply
- δ_{sj} is the demand price elasticity of supply
- ε_s is the network access elasticity of supply, and
- ξ_s is the network capacity elasticity of supply.

A priori, the sign of the own price coefficient is negative, whereas the cross-price coefficients are expected positive. A lag supply response to ICT and technology investment is also considered.

The *demand equation* for product *j* is:

$$\ln y^d_t = a_d + \beta_d COMPNRS_t + \\ + \sum_j \gamma_{dj} \ln P_{jt} + \sum_j \delta_{dj} \ln y^s_{jt} + \quad (1.2) \\ + \varepsilon_d \ln EMP_t + \xi_d \ln SPEN_{t-1} + \nu_t$$

where

- y^d_t is product *j* demand
- $COMPRNS_t$ is competition in network-related service markets
- P_{jt} is product *j* price
- y^s_{jt} is the supply of product *j*
- EMP_t is SMEs, MNCs, and LEs headcounts
- $SPEN_{t-1}$ is SMEs, MNCs and LEs expenditure on ICT products, and
- ν_t is a random error term
- β_d is the NRS competition elasticity of demand
- γ_{dj} is the own-price elasticity of demand
- δ_{dj} is the supply price elasticity of demand
- ε_d is the SMEs, MNCs and LEs headcounts elasticity of demand
- ξ_d ICT expenditure elasticity of supply.

A priori, the own price coefficients are assumed negative, while the cross-product price parameters are assumed positive.

Model 2

In Model 2, ICT product supply functions are of the form:

$$\ln y^s_t = a_s + \beta_s \ln INV_{t-1} + \sum_j \gamma_{sj} \ln BUNCAT_{jt} + \\ + \sum_j \delta_{sj} \ln y^d_{jt} + \varepsilon_s \ln NC_{t-1} + u_t \quad (2.1)$$

where

- y^s_t is product supply
- INV_{t-1} is ICT and technology investment
- $BUNCAT_{jt}$ is the bundled (and catalogued) product price
- y^d_{jt} is product *j* demand
- NC_{t-1} is network capacity, and
- u_t is a random error term
- β_s is the ICT and technology investment supply elasticity
- γ_{sj} is the own price supply elasticity
- δ_{sj} is the own product demand supply elasticity, and
- ε_s is the network access supply elasticity.

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A priori bundle (and catalogued) product price is assumed negative. All remaining price parameter values are assumed positive. The lagged demand response to ICT investment and technology and network capacity change represents the ability to supply broadband.

The *demand equation* for the product is:

$$\ln y_t^d = a_d + \beta_d COMPNRS_t + \\ + \sum_j \gamma_{dj} \ln BUNCAT_{jt} + \sum_j \delta_{dj} \ln y_{jt}^s + \\ + \varepsilon_d \ln EMP_t + \xi_d \ln y_{t-1}^d + \nu_t \quad (2.2)$$

where

- y_t^d is product *j* demand
- $COMPRNS_t$ is competition in network-related service markets
- $BUNCAT_{jt}$ is the bundled (and catalogued) product price
- y_{jt}^s is the supply of product *j*
- EMP_t is SMEs, MNCs, and LEs headcounts
- $y_{t\text{-}1}^d$ is demand for the product/service in time *t*-1
- ν_t is a random error term
- β_d is the NRS competition elasticity of demand
- γ_{dj} is the bundled (and catalogued) product price elasticity
- δ_{dj} is the supply elasticity of demand
- ε_d is the SMEs, MNCs and LEs headcounts elasticity of demand
- ξ_d is one period lagged demand elasticity

A priori bundled (and catalogued) product price parameter is assumed negative. All the cross-product price parameters are assumed positive. Also specified is a lag demand response.

4 Estimation Results

Estimated parameters for the supply equations are presented in Table 2. The estimated parameters for the corresponding demand equations are contained in Table 3. For model validation, only the Durbin-Watson and t-statistics are reported. However, other statistics were calculated but are not reported here.

4.1 Supply Equations

Model 1

The estimated INV parameter is inelastic, except for 'Mobile Data' services. While investments in technology commonly impacts on supply and demand, the low elasticity only reflects the immediate effect, ie. there may be a more complex temporal pattern ignored by this specification. The estimated product price parameters are signed correctly, except for 'Communication Services'. 'Data', 'IT Infrastructure' and 'Desktop Management' services are relatively elastic in supply. The estimated network capacity parameter is inelastic for all products, and results from the specified lag structure or indicates that network capacity (especially broadband) is a commodity with customers expecting high capacity at low prices. The estimated demand parameters exceed unity for 'Data', 'Mobile Data' and 'IT Infrastructure' services, which means the demand impact on supply is

Variable		Data	Voice	Mobile data	Mobile voice	Communi-cations	Applicative solutions	Desktop management	IT infra-structure
Model 1									
Constant		**11.72**	**21.12**	11.15	**0.73**	**1.29**	**9.58**	-0.39	**12.17**
ICT investment (*t*-1)	INV_{t-1}	**0.42**	**0.56**	**1.07**	**0.91**	**0.82**	**0.72**	**0.56**	**0.47**
Product price	P	**-1.58**	-1.17	-0.87	**-1.03**	**0.24**	**-1.02**	**-1.41**	**-1.09**
Demand	y_{jt}^d	**1.77**	0.98	**1.02**	**0.98**	**1.02**	**1.19**	**0.66**	**1.37**
Network access	NA	0.31	0.41	**0.57**	**0.72**	**0.54**	**0.92**	**0.59**	**0.59**
Network capacity (*t*-1)	NC_{t-1}	0.65	**0.59**	**0.69**	0.01	0.68	**0.39**	0.38	0.88
$\bar{R}^2$		0.68	0.94	0.76	0.69	0.97	0.96	0.86	0.89
Durbin-Watson		1.66	1.97	1.42	1.68	1.13	2.01	0.98	1.67
Model 2									
Constant		**9.17**	**9.23**	**21.16**	7.14	**9.27**	**5.17**	0.72	**11.82**
ICT Investment (*t*-1)	INV_{t-1}	**0.57**	**0.59**	**0.85**	**0.73**	**0.43**	**0.88**	**0.89**	**0.62**
Bundle price	BUNCAT	**-0.46**	**-1.12**	-0.19	**-1.24**	**-0.76**	**-1.73**	**-1.19**	**-1.27**
Demand	y_{jt}^d	**0.92**	**0.85**	**0.64**	**0.69**	0.41	**0.88**	**0.59**	0.19
Network capacity (*t*-1)	NC_{t-1}	**0.51**	-0.17	0.94	0.58	**0.98**	**0.71**	0.19	**0.83**
$\bar{R}^2$		0.93	0.88	0.73	0.91	0.79	0.95	0.77	0.91
Durbin-Watson		1.94	1.54	1.33	1.89	0.86	1.62	1.95	1.17

Table 2 Estimated Supply Model Parameters (parameters printed in bold are significant at the 5 % level)

important. However, a longer lag might provide a more elastic estimate.

Model 2

All estimated INV parameters are inelastic. ICT investment substantially impacts on supply. Again, the results suggest that investigation of a more complex geometric lag structure may prove informative. In this model, negotiated price (BUNCAT) replaces ARPU. All price parameter estimates have their expected signs, with most products more supply-elastic than in the Model 1 specification. As in Model 1, the estimated 'Network Capacity' parameters are inelastic, which suggests that network capacity (especially broadband) is a commodity.

4.2 Demand Equations

Model 1

The estimated NRS competition parameters are less than unity. The positive impact suggests that competitive forces stimulate demand. However, as the products are standardized they are distinguished only by delivery, price and ability to manage complex IT and telecommunications projects. Accordingly, the number of suppliers appears less important than anticipated. The reported price parameters are correctly signed, however, demand is elastic. The estimated supply parameter value is less than unity for all products, except 'Voice', 'Mobile Data' and 'Communications' services, which suggests the integration of delayed supply in the demand equation. The estimated expenditure is elastic for 'Data services', 'Mobile Data' and 'Applicative Solutions' services.

Model 2

As for Model 1, the NRS competition parameters are less than unity, and naturally the conclusions carry over. The estimated parameters for negotiated prices are correctly signed. Via comparison with Model 1 demand is uniformly more price elastic (with most reported price elastic). Further, the enterprise (SMEs, MNCs and LEs) headcounts parameter is positive and inelastic. This result accords with the interpretation that an increase in headcounts more than matches growth in customer need.

About seasonality and lagged variables structure, we tested alternatively up to 4 lags for the following variables: NC (network access), SPEN (SMEs, MNCs and LEs expenditure in ICT), INV (investments) and y_t^d (demand). We did not have significant improvement in terms of fitting when the lagged period exceeds one lag (t-1), and lags are not significant (t test). On the other hand, we should keep in mind that (a) the short data set (33 observations on French ICT market), (b) the number of endogenous variables in models, and (c) the transformation of the original data set – from annual data to quarterly data – could be a significant limitation of the use of too much lagged variables.

Figure 3 depicts Model 2 actual and estimated *aggregate demand*. Figure 4 shows the corresponding quarterly errors. Errors over 5 % concern mainly Q2 (2000, 2006 and 2007) and Q4 (2000, 2001 and 2005).

Variable		Data	Voice	Mobile data	Mobile voice	Communications	Applicative solutions	Desktop management	IT infrastructure
Model 1									
Constant		**-6.89**	-15.08	**-8.67**	-0.75	-9.77	**-8.41**	-2.17	-1.26
NRS competition	COMPNRS	0.19	0.37	**0.85**	**0.87**	**0.42**	**0.78**	0.47	**0.57**
Product price	P	-1.62	**-1.04**	**-2.01**	-1.41	**-1.28**	**-1.33**	**-1.66**	**-1.01**
Supply	y_t^s	**0.95**	**1.28**	**1.12**	**0.79**	**1.34**	0.78	**0.59**	**0.87**
Enterprise headcounts	EMP	**0.48**	0.80	**1.09**	**1.94**	**0.85**	0.34	**0.97**	**1.27**
ICT spendings (t-1)	$SPEN_{t-1}$	**1.14**	0.95	1.41	0.09	0.58	**1.12**	**0.73**	**1.07**
$\bar{R}^2$		0.67	0.86	0.89	0.98	0.77	0.55	0.75	0.96
Durbin-Watson		1.04	1.81	1.35	0.79	1.92	1.76	1.38	1.67
Model 2									
Constant		-7.05	-7.72	-1.59	-0.95	**-2.71**	**-9.29**	**-5.88**	0.25
NRS competition	COMPNRS	0.42	0.44	**0.75**	**0.67**	**0.56**	**0.85**	0.49	0.48
Bundle price	BUNCAT	**-1.08**	**-1.56**	-1.66	**-1.77**	**-1.53**	**-1.84**	**-1.36**	**-2.16**
Supply	y_t^s	**0.95**	**0.84**	**0.39**	**0.85**	**0.71**	0.77	**0.86**	0.51
Enterprise headcounts	EMP	**0.25**	**0.18**	**0.95**	**0.69**	0.15	**1.02**	**0.75**	**0.97**
Demand (t-1)	y_{t-1}^d	**0.98**	**0.84**	**1.92**	**1.53**	**1.88**	**2.33**	**1.95**	**1.18**
$\bar{R}^2$		0.96	0.85	0.96	0.91	0.66	0.85	0.95	0.94
Durbin-Watson		1.72	1.53	1.49	0.86	1.84	1.38	1.42	2.17

Table 3 Estimated Demand Model Parameters (parameters printed in bold are significant at the 5 % level)

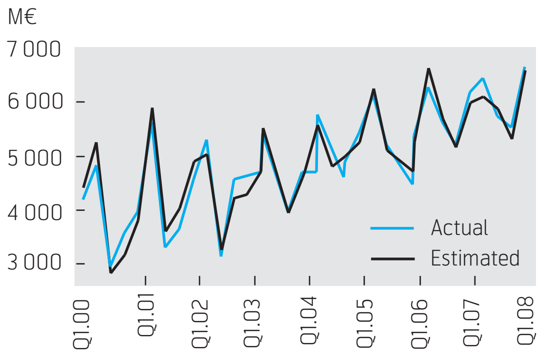

Figure 3 Model 2 Estimated and Actual aggregate demand

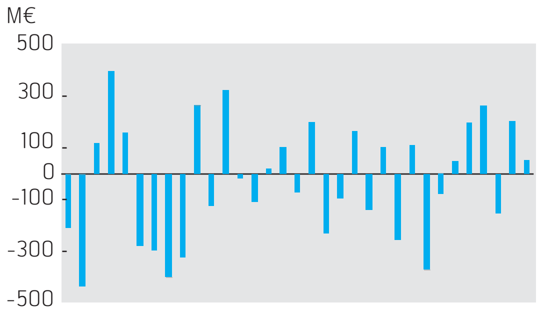

Figure 4 Model 2 Errors of aggregate demand

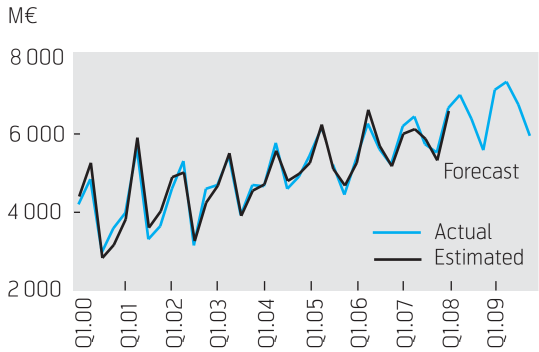

Figure 5 Forecasts of the ICT business market in France (2008-2009)

It is important to note at this stage that some series involved in some econometric models are non-stationary. This assumption is confirmed by Dickey-Fuller test (D.A. Dickey and W.A. Fuller 1979). When true, it could be interesting to take this non-stationary phenomenon into account in modelling through an Error-Correction Model (ECM).

As series are integrated, this could explain the high values for $\bar{R}^2$ statistic in many models. So estimating an ECM that takes also the seasonality into account could strongly improve the consistency and credibility of the models.

5 Forecasts

Figure 5 forecasts trend aggregate demand for the French business market (Q2-2008 to Q4-2009). The forecasts are consistent with commercially available projection and benchmark forecasts of French ICT demand with differences (in aggregate demand) of 2 – 3 %. However, the slowdown of some main drivers in ICT industry, such as economy (GDP), investments in innovation and technology (INV) and in the expenditures and spending should be integrated in the model.

6 Conclusion and Further Work

Although recent technology waves shape ICT business markets, enabling enterprise IP transformation, competition, price and bundles and innovation and technology investment remain important variables in explaining market growth. The modelling addressed the deployment of new technology (3G+, IPBX) for which observations are available. The estimations suggest that model specifications are robust, and validate the simultaneous equation modelling approach. Several refinements are being considered.

In particular, data are being gathered on variables related to new ICT products, especially security, hosting and professional services. Further, the analysis intends to focus on market segments such as Internet and broadband access, managed services and data WAN.

Compared to our previous study (M. Hamoudia and M. Scaglione, 2007), the refinements we did on data (many quarterly data were adjusted, especially for 2007, as they were temporary). However, the data set size (33 observations) could be a limitation in the model accuracy.

As highlighted in section 4.2 (page 103), some series involved in these econometric models are non-stationary. This assumption is confirmed by Dickey-Fuller test. It is interesting to take this non-stationary phenomenon into account in modelling through an Error-Correction Model (ECM).

The fact that the series are integrated could explain the very high values for $\bar{R}^2$ statistic in many models. So estimating an ECM that takes also the seasonality into account could strongly improve the consistency and credibility of the models.

Finally, the lag structure requires more investigation. The different simulations on lagged variables (up to four lags) have not shown any significant improvement in terms of fitting. Despite this, we think that for instance, intuitively ICT and technology investment should impact on demand for more than a quarter.

Appendix 1 Data Sources

Information about variables on *Supply* and *Demand* blocks for ICT are available in some studies published by consultancy offices such as Datamonitor, Forrester Research, Gartner, Idate, Ovum, Markess International, IDC and JupiterResearch. A number provide detailed databases on various ranges of services.

We used also annual and quarterly reports published by Companies (IBM, Atos, Capgemini, BT, Orange, Telefonica, T-Systems, AT&T, Verizon, ...). As most of such sources of information are annual, and as the model is based on quarterly data, we used two approaches to convert annual data into quarterly data:

a The quarterly reports that companies publish in the US (to meet the US Securities and Exchange Commission obligations) provide legal information and reports. This may make it easier to estimate quarterly seasonality and apply it to other data.

b The second approach is based on the Chow-Lin procedure for quarterly interpolation of annual data (Chow, G and Lin, A L, 1971) and (Pavía Miralles, J M, Vila Lladosa, L-E et al, 2003).

c Information on the *Environment* is generally abundant except in the case of *Regulation*. Data for the *Economy* were tracked from Eurostat (European Union Office of Statistics) and the National Statistical Office in France (INSEE). Both sources provide monthly, quarterly and annual data, by industry and by other segmentations. Unfortunately, there are serious data limitations with *Regulation* variables such as the *Level of openness of the market, local competition loop*, and *interconnection*, as this information is more qualitative and sometimes confidential. We used dummy variables to run our modelling approach as many variables represent generally qualitative effects, such as the level of openness of the market, and the IP transformation level of MNCs, SMEs and LEs. They are therefore either dummy or designed to take into account the variable impact of a variable. For example, the level of openness of the market has been sized from 1 to 5, meaning from a low level to fully open market.

The last issue we faced is the short data set for the majority of new products and services variables, such as 3G, 3G+, ADSL+, VoIP, IPBX, and Security. This could be a limitation if we integrate the impact of new offers and services on the core business into the model.

Statistical Sources

INSEE: Comptes trimetriels 2007

Eurostat: Dépenses consacrées aux TIC – Télécommunication – Dépenses consacrées aux technologies de la télécommunication 2007

Annual and quarterly reports 2000–2006: France Telecom Group, BT GS, IBM, Atos Origin, Verizon, AT&T, Telephonica, T-Systems.

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