Technological cooperation and product substitution in UK retail banking: the case of customer services

Davide Consoli

Abstract: The pervasive implementation of Information Technologies paved the way to significant transformations in the retail banking sector, including organizational changes as well as a broader product range. The central theme that is discussed in this paper is the degree to which the unfolding of a technological trajectory provided incentives to agents for the creation of absorptive capacity and the subsequent array of adjustments in the demand and the supply of banking services. Accordingly, two phenomena are especially relevant for the purpose of this analysis: the emergence of a network structure in the UK retail banking system and the product substitution effects that emerged in the demand side.

Keywords: Retail Banking Services Innovation, Cooperation, Consumption.

JEL Classification: G21, L8, O31, D91.
1. Introduction

The central aim of this paper is to review the emergence of a technological system and the subsequent structural changes stimulated in UK retail banking. Technical change and, in particular, the development of Information technology (IT) played a pervasive role in redefining the boundaries of this activity. Commercial banking has gone through significant changes with respect to at least two dimensions: internally, the emergence of a network structure as a workable solution to avoid bottlenecks that could hinder the capacity expansion of the activity; externally, the enlargement of the number and the variety of services stimulated by the feedback of customers. This paper will focus on the intertwined effects of the implementation of a general purpose technology and the subsequent cascade of complementary changes that biased the composition of the techniques used to provide retail services.

In the conceptual framework proposed here the fact that economic agents learn from accumulated experience yields that they are able to generate variety when performing their activities whilst ensuring the persistence of characteristically localized features. These complementary forces sustain the diachronic adaptation of banks’ organizational structure with the growth of customers’ capabilities and preferences to the increasing variety of activities and products involved. The assessment of such a process is primarily developed on historical basis for it is in the unique succession of random events and subsequent adaptive choices guided by learning that the roots of irreversibility of most economic processes reside.

Some aspects of change in retail banking needed be left out of the paper to maintain its focus and clarity: in particular, whilst deserving a separate digression, the development of capital markets and the issue of regulation will simply be outlined. The paper is structured as follows. Section one will review the technological events occurred in UK retail banking through a long term longitudinal analysis in order to set the conceptual framework for the analysis of the diffusion of innovations in that sector. The next two sections will focus on the sources and the effects of technological cooperation and demand adjustments as guiding forces of a dynamically adaptive process.

2. UK retail banking services: dynamism and diffusion

The process of innovation in retail banking services required a continuous adaptation of the organization of labour to newly emerged technical instances aimed at improving the provision of typical functions such as storing, manipulating and transferring information over time and
space. The capacity and the quality of this transmission represent the core of most banking services and determine their value. The long-run timeline of technological developments in retail banking is here divided into four phases: the passage from Electric to Electronic Communication (1900-1945); the development of Processors and Database (1945-1968); the emergence of Automated Machines and Local Networks (1968-1980); the establishment of an integrated network (1980-1998). Table one provides a synopsis of these events.

**TABLE ONE ABOUT HERE**

This historical background leads to the observation that the growth of services in commercial banking need be related to the coordination between old and new tasks within an emerging technological paradigm. The argument is developed in this work by looking at retail banking as a hierarchical set composed by interdependent parts which, unlike those of an aggregate, acquire their characteristics from the whole and through their interplay generate and sustain innovation. It seems appropriate at this point to recall the contribution of Thomas Hughes (1983) who described the development of large technical systems as a process characterized by three phases: invention, technical transfer and overall growth of the system. The path leading to the last stage in which the system is fully integrated and generates the resources necessary for further development, however, proceeds along an uncertain and discontinuous pattern characterized by the emergence of contextual problems, or reverse salients. In this perspective, it is important to distinguish a twofold dimension of technological change: one relative to the impulse provided by the emergence of a new technological system, the other consisting in the propagation of such effects through the changes that occurred non homogeneously across the ensemble of activities.

Table one provides only a static account of the events that characterized the implementation of IT in retail banking and, thus, cannot capture properly the process that led to the realization of a high degree of interrelatedness between the components of such a system. In figure one this historical process is instead represented by linking the technical events to the ramifications generated by the adoption of new technologies and the trajectories derived by an array of diverse, yet complementary applications. These trajectories are schematized in two dimensions: cumulative and transformative. The cumulative envisages the upgrade of the current set of competencies aimed at generating some new, albeit qualitatively stable, activity. As an example the automation of back office procedures stimulated quantitative changes for it allowed a higher number of operations leaving the nature of the activity unchanged. Hence, in the framework

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1 Detailed analysis on the historical development of UK retail banking can be found in Batiz-Lazo & Wood, 2000; Consoli, 2003.
presented here such short-term effects are the immediate consequence of general purpose technologies. At the same time, the importance of indirect influences transmitted via specific linkages through the development of new artifacts specifically developed for the banking activity cannot be neglected. The other dimension, transformative changes, accounts for the creation of new functional uses, thus of new economic purposes, reflecting the redistributive process of cognitive elements that usually generate new patterns of change and the related indirect effects. Arguably, this dimension will include the creative application of qualitatively new routines out of learning that impinges more upon the behaviour of the agents the higher the economies of scale due to increase of the volume of transactions. Hence, qualitative issues become involved when assessing events such as the passage from cash dispensers to automated teller machines, or the emergence of an integrated network built upon a combination of several technologies².

FIGURE ONE ABOUT HERE

The diagram provided here illustrates the evolution of a number of related activities in the banking sector after the implementation of a number of general purpose technologies. In such a framework complementarities are crucial for they constrain the development of a new technology by creating a set of interdependent routines. The historical observation of events and their casual relations over time constitute the basis for the emergence of irreversibility in the process under observation. Technologies permeate economic activities at multiple levels, from the organizational arrangements of business units, to the macroeconomic composition of industrial sectors. Conversely, when attempting to evaluate the contribution of a distinct innovation to a production process, one will need to take into account the relative importance that a specific ensemble of interrelated techniques has across this array of different configurations. In particular, when the economic system is heterogeneous technical change cannot be neutral for the actual configuration of techniques is subject to a varying degree of returns, hence, one particular technique, or a combination of more, will display positive feedback as a response to a specific innovation (David, 1975; Antonelli, 2003a). Irreversibility in productive processes stimulates and, at the same time, constrains the pattern of structural change its extent being wider the stronger the degree of interrelatedness. The contingency of production techniques and of their composition plays hence a crucial role in determining the direction of technical change. In the case of banking services, the dynamics of the division of

² Antonelli’s (2003b) distinction between neutral and contingent technological change offers a good conceptual background for the understanding of the two effects observed here.
labour amplified the effects of the emerging technological system. Three broad categories of staff can be identified in UK commercial banks: the tellers, who carry out cash-related transactions; the clerks in the front office; the managerial staff. In the early days of the processor several UK banks deployed back-office terminals which enhanced the data processing creating a fast and reliable information storage. This, in turn elicited the necessity to develop internally dedicated processes such as databases and a shift in the composition of labour from routine clerical functions in favour of specialized management-oriented and technology-oriented tasks, such as software developers. Notably, the cascade of technological processes that followed the introduction of the processor in banking affected the annual average growth of employment in UK banking which declined for a period of 20 years until in the mid 1980s (Child & Loveridge, 1990).

TABLE TWO ABOUT HERE

In a wider perspective this process determined the reduction of the branches which together with the increasing number of Automatic Teller Machines deployed in the UK provide an insight of how the implementation of IT impinged upon the structure of the banking sector (Consoli, 2003).

TABLE THREE ABOUT HERE

As outlined by the sequence of events, the development of a system is stimulated and, at the same time, constrained by the solution to contextual problems giving rise to the emergence of interrelatedness among the subcomponents eliciting complementary adjustments such as the reorganization of working schedules or the creation of new professional, task-oriented figures. These changes create positive feedback sustaining the diachronic adjustment between the external and the internal functions of banking, a process which was made viable through the definition of network standards (Antonelli, 1994; Metcalfe & Miles, 1994). The changing relation between major processing systems and their specific applications define the coevolution of the functional design of a product with its applications. In this perspective, cognitive capacity, technical abilities, sector specificity and consumers’ manifested needs all represent localized features of the development of services and their repeated interaction ensures the self reinforcing mechanisms that qualify such a system as autocatalytic (Metcalfe et al, 2003). The following sections will focus on the nature of these mechanisms and, in particular, on the microfoundations of technological change analyzed through the assessment of the incentives and the constraints that guided agents’ decisions.
3. Technological cooperation in retail banking innovation

Banking services provide flexibility and reliability of information over time and space hence the employment of dedicated inputs such as technical devices for the management of information became a crucial roundabout to confront the reverse salients stimulated by the emergence of the new IT paradigm. Commercial banking has particularly benefited from the flexibility of technology to foster the expansion of processing capacity and the subsequent diversification of processes and products (Carlsson, 1989; Novo-Peteiro, 2000). However, such an expansion brought about cyclical changes in the structure of the banking system. This occurred in the early 1900s, before the introduction of automated processes, when banks became notably fewer but larger on average and established geographical coverage through branching. Similarly, it occurred when the consolidation of clearing arrangements entailed a higher volume of transactions compelling new challenges such as increase of efficiency and of profitability.

Investments in the implementation and development of Information Technologies (IT) whilst primarily aimed at the exploitation of enhanced processing capacities, in fact altered non-homogeneously the relative efficiency of the techniques employed and, also, the organization of labour across banks. The first phase of automation opened the way to dispersed innovations like cash machines and automatic tellers but by the end of the 1960s banks begun to confront the possibility of bottlenecks arising from the saturation of the activity due to the limited integration of interbank transactions which involved extra costs and time. The creation of an integrated banking network emerged as a viable solution to these potential drawbacks due also to the consolidation of a common knowledge base as a mechanism of governance, an indispensable feature in a system of interacting agents who share common localized resources (Antonelli, 2001; Potts, 2000). The prospect of regulated interaction elicited coordination at several levels since banks, being not vertically integrated, were subject to the adjustment of the productive capacity of upstream suppliers. The practical answer to these coordination issues was the creation of an array of formal and informal arrangements with coexisting firms and suppliers. Finally, banks sought strategic complementarity by stimulating the development of dedicated activities, such as software development, internally in order to overcome barriers to coordination which might have hindered the effective emergence of the network structure (Gordon, 1981; Earl, 1998).

As suggested by Hughes, dealing with a coordination problem brings about a composite assortment of changes at single business unit level as well as at sector level. To better grasp the nature of the incentives that qualified technological cooperation as a solution to the limitations
of a scarcely integrated network in UK retail banking, a formal specification is in order. Consider a new input providing advantages over existing ones, as in the case of the processor employed in commercial banking from the 1950s. This implementation opened the way to a new market for innovation which primarily expanded banks’ capacity supply of services as a consequence of their ability to manage more information in less time. It is possible to identify two crucial moments in the unfolding of this new technological trajectory. Initially, the impulse provided stimulated greater absorptive capacity whose actual exploitation, however, depended on the dynamics of the division of labour. Back office re-organization is one key example of how the internal procedures of banks were adapted to the expanded capacity resulting in skills creation and development of task oriented personnel. This process of expansion eventually reached saturation as the capacity expansion outgrew the actual development of the activity due to coordination costs. Conversely, another crucial moment coincided with the emergence of a network which represented a solution generated from within (eg the solution to a reverse salient) to allow capacity expansion in proportion to its potential. The magnitude of the changes in a sector is usually proportional to the interlinkages that exist within agents operating in that sector: the more connected are agents, the more pervasive is the solution to coordination problems. Commercial banking was no exception. It is possible to analyse the transition from one method of provision to the other by considering the set of incentives at stake.

Consider the banking system as a set formed by N units bearing a transaction cost which increases with the number of banks, hence with the absolute scale of the activity, in absence of a network. These costs are due to the lack of coordination among interbank transactions involving idiosyncratic procedures across the set of banks, a situation very similar to the one confronted by banking firms in the 1960s in the UK. To understand the mechanism at work that elicited the emergence of a network structure in this case, one need looking at the set of incentives and constraints at stake. In the framework under observation the guiding rule is that a bank will make the decision to join the network or not on the basis of the costs and the returns involved by this investment. Assume each bank \( j \) will confront the profits realized by providing a service in the network \( r_N \) against those linked to provision outside the network \( r_{i \neq N} \). Consider the rate of relative profits

\[
    r_j = x(t)_j \left( \frac{p_n - c_h}{A_j} \right)
\]

(1)
depending on the excess of the price \( p_n \) of the service over its direct cost \( c \) per unit of input \( h \).
The latter will be purposefully weighted in this model by the share of overall output \( X(t) \) accounted for by each bank, \( x_j(t) \), and by the indirect cost of coordination \( A \). The latter will depend on the density of the network \( n^{-1} \) which is an inverse function of the banks:linkages ratio. Linkages will include any alliance or arrangement that makes possible to coordinate banks’ activities and, hence, to reduce the coordination costs. In absence of a network, an isolated bank will bear a cost \( A \) which is directly proportional to \( N \). Conversely, for a bank operating within a network the negative effect of the magnitude of \( N \) is mitigated by the increase in linkages \( l \), hence by coordination. In the case of a bank \( i \not\in N \) it will be assumed for simplicity that \( l = 1 \) and \( A_i = \Phi(N) \) whereas for any bank in the network it will be \( A_N = \Phi(N/l) = \Phi(n^{-1}) \); \( dA/dN > 0 \), \( dA/dl < 0 \).

The growth of the network \( N \) can be measured endogenously by setting up an expression for the rate of expansion of its density \( n \). To accomplish this, we need employ a particular version of the Fisher’s Principle commonly used in evolutionary economics (Metcalfe, 1998; Metcalfe 2001b) to relate the impact of the differential profits to the rate of growth of the share of each bank within the network. The excess profits realized within the network represent here a selective advantage that determine the growth of the share of each bank in \( N \). Knowing that the rate of increase of the total population in the network is \( N = \sum s_N r_N \), with \( s_N \) the share of a bank in the network, structural change and differential growth can be linked in the following expression

\[
\frac{dn}{dt} = \sum_N s_N (r_N - r_i) r_N + \sum_N s_N \frac{dr_N}{dt}
\]

Equation (2) encompasses the mechanisms of market selection and of development within the network\(^3\). The selection process determines whether a bank will join the network (or not) according to the rule \( r_N > (<) r_i \); the developmental process, the second term, describes the intertwined process of consolidation of the share with the profit level of each bank within the network.

Arguably, the framework that we are suggesting differs from other approaches to the analysis of network effects in at least two features. Where the units of a population joining a network are generally assumed to be homogeneous, their differential profitability is a distinguishing feature in the framework presented here. Indeed, the rate of relative profits here is crucial in

\(^3\) Obviously, the relation between the linkages and the number of banks is given by \( l = \frac{N(N-1)}{2} \) but the aim of this paper is to present an endogenous determination of \( N/l \).
determining the speed at which the density of this network grows. Moreover, the profits are linked directly to the share of overall output accounted for by each a bank, which is the aforementioned distinguishing characteristic. Therefore, it might be suggested that if a “big” bank decides to join the network early – as it effectively occurred in the UK – the process will be speeded up more than it would be in the case in which a relatively high number of small banks joins. This is to be understood as an effect of the relative advantage accrued by big banks with a high number of outlets and facilities, including the automated machines that will accrue density to the network. More generally, in the case under observation the rate of network growth has a qualitative component other than the well known bandwagon effect.

To fully capture the sense of these interrelated observations it is time to spell out the components of the rate of relative profits. Consider the cost function first. Depending whether one bank joins the network \( (N) \) or not \( (i) \), it will be

\[
\begin{align*}
    c_i(t) &= c_0 + c_i X(t); \\
    c_N(t) &= c_0 \left( \frac{N}{l} \right) + c_{1N} \sigma(n)X(t)
\end{align*}
\]

The superfixed costs \( c_0 \) path is decreasing the higher the number of linkages \( l \) whereas the variable cost \( c_{1N} \) is a decreasing function of the fraction of shared inputs \( \sigma \) across the network. Hence, \( d\sigma/dn > 0 \).

The creation of a network in retail banking does not alter directly the nature of the services but rather the way these are provided. In our analysis this corresponds to the creation of a new niche in which capacity expansion will determine the long-run path of the new service provision. At the same time however, potential users play a crucial role in determining the rate of diffusion of new products by adapting to their characteristics out of a learning processes. Indeed, the growth of a niche is determined by the interplay between the growth of demand and of capacity expansion along a balanced pattern (Metcalfe, 1981; Metcalfe & Cameron, 1987; Metcalfe, 2003).

It is worthwhile to recall why this argument applies to the case under observation: the need for a network in retail banking was stimulated by the reached limits of capacity in the supply of financial services provided by non integrated banks. Without demand growth there would be no

\[\text{(3)}\]

\[\text{The long-run relations are assumed to be linear to make the problem more easily tractable.}\]
profits to reinvest in the productive processes and without an adequate supply, the growth of demand would face constraints and the expansion of new technologies would be hindered.\(^5\)

Consider now the rate of increase in market demand for the new provision modes of services to be represented by a logistic function

\[
g_D = \frac{dX(t)}{dt} = \beta X_n(t)[a - bp_n - X(t)]
\]

\[(4)\]

were \(X=a - bp\) is the demand curve for services in the network \((a, b\) constants) and for any given price \(p\) the niche will be filled at the rate \(\beta\). The hypothesis of a logistic demand function seems consistent with the case under observation of technologically intense services. The consumption of the first units will require some learning, expressed by the constant demand diffusion coefficient \(\beta\) which will entail a fast growth in demand beyond a critical threshold of number of accesses. After that, the demand for services will approach at a progressively slow rate the ceiling. Arguably, the critical value at which the demand curve will begin to approach the asymptote will also depend on the number of units demanded in relation to the capacity adjustment of the output. In a regime of intense use of services, their supply might entail excludability. For these reasons it is necessary to analyse the growth of capacity supply linked to the profitability of the services since it is assumed that investments in the new niche are funded by profits generated both by inside and outside the network.

Consider the ratio \(\nu/\pi\) expressing the share of network profits to internal profits that are reinvested in growth capacity expansion and substitute (3) in (1):

\[
g_S = \frac{dX(t)}{dt} = \frac{\nu}{\pi} r(t) = \frac{\nu}{\pi} x_N(t) \left[ p(t) - \left\{ c_0 \left( \frac{N}{l} \right) + c_1 \sigma(n) X(t) \right\} h \right]
\]

\[
= \frac{x_N(t)}{m} \left[ p(t) - k_0 - k_1 X(t) \right]
\]

where \(k_0 = c_0 (N/l)h\) is the prime cost and \(k_1 = c_1 \sigma(n) X(t) h\) is the marginal cost depending on the overall scale of production; \(m^{-1} = (\nu/\pi)(1/A_j)\) is the portion of network profits required to expand the network capacity. The growth of capacity will follow a logistic curve whose saturation level depends on the difference between the price and the threshold of direct and

\(^5\) It is also interesting to notice that the ceiling of the process of technology growth and substitution is a moving threshold over time. The determination of the rate and direction might be object of further explorations.
indirect costs. The carrying capacity of this process equals \( x = (p - k_0)/k \) hence with a constant price the profitability of the investment will decline as the output – and correspondingly the input prices – expand.

If the price were given, the growth of demand and of supply would have a different equilibrium asymptote. This mismatch can only be balanced through the endogenous adjustment of the price of the new service. This will be given by rearranging (1) considering also (5):

\[
p_n(t) = \frac{\pi}{\nu} \left[ \frac{A_j}{x_N(t)} \frac{dX(t)}{dt} \right] + k_0 + k_i X(t) = m \left[ \frac{1}{x_N(t)} \frac{dX(t)}{dt} \right] + k_0 + k_i X(t) \tag{6}
\]

The price path that ensures a balanced growth of capacity expansion and demand is determined by the profit margin necessary to expand the network capacity in addition to the long-run unit costs. As confirmed by the observation of the retail banking system in the UK, the expansion of the network depends on the direct consequences of the availability of superior technologies and on the indirect effects of an increase of shared knowledge which stimulated the growth of the network diminishing the variable costs. Hence, the incentive to pursue technological cooperation increases as technology becomes more specialized and agents establish an array of shared routines around a set of localized production factors. In such a system, the quality of communication plays a dual role both at inter-population (e.g., among network and non-network agents) and intra-population (e.g., within the network) level. As Antonelli (1997) argued, in a network where shared inputs are subject to increasing returns the efforts made by agents to achieve a complete connection will increase the probability of a phase transition and, in turn, will impact positively on the innovative efficiency of the system. Learning processes play a major role in this variegated ensemble of causations for they determine the rate and the direction of these interdependent adjustments within an emergent technological trajectory (David, 1975).

Following the expansion of absorptive capacity through the creation of a network in the UK retail banking industry, a bias emerged in the elasticity of production factors and in the composition of the output so several banks diversified their activity expanding into new business lines such as credit cards, stock brokerage, investment management services and insurance in order to confront the competitive pressures of an increasingly homogenous sector. The realization of this process of diversification, however, required a complementary response in the demand side of the market. Consumers initially faced the costs associated with learning how to use new products but as soon as imitation and interdependence emerged in their preferences, they stimulated demand externalities which compelled further differentiation and specialization in the use as well as in the production of new services. To capture the effects
stemming from product competition it is thus necessary to look at the substitution effects observed in the demand side of the market and to relate these to the expanded growth capacity attained by means of the newly emerged network.

4. Product substitution in retail banking services

As observed in the previous section, the development of IT and the emergence of a new division of labour provided the appropriate incentives for the formation of an integrated network in the retail banking system of the UK. Until then competitors in such a market pursued incremental innovation strategies based on heterogeneity across factor markets, however when banks enabled the outlined process integration they also created a bias in the future innovation strategies towards a homogeneous utilization of production factors consistent with the newly emerged technological trajectory. The pervasive application of general-purpose technologies, thus, eliminated cost asymmetries between competitors whilst stimulating niche strategies aimed at the introduction of product innovations which would present idiosyncratic characteristics with the existing range of customer services. Under the strategic point of view, this brought about an intense product competition in which, through differentiation, banks could pursue niche strategies in the attempt to recreate the conditions for a localized monopoly on the set of products’ characteristics rather than, as previously, on specific geographical areas (Antonelli, 2003a).

This analysis needs be complemented with the assessment of the demand effects observed in heterogeneous consumers facing the emergence of new, idiosyncratic, services. Heterogeneity across consumers stimulates niche strategies and is, in turn, reinforced by a high degree of diversity among products. In such a context, quality issues arise due to the strict complementarity existing between idiosyncratic bundles of products. Cash machines, Automatic Tellers and integrated financial kiosks are artefacts that offer enhanced access to a bundle of services which are partially overlapping. Although the nature of the service is not changed in its core function, by means of these new artefacts the quality of the access to them is improved by the introduction of such new interfaces. Quality however, is a relational concept that is best accounted for when, given the prices, it is possible to relate changes in demand of an existing product to the introduction of a complementary one. Hence, some customers will substitute the old product with the new one although the former will continue to exist with its idiosyncratic characteristics. In this case cross demand elasticity to price is less than infinite since product substitution is not perfect and there would be partial overlaps in the purchase of complementary
The scope for substitution will depend on how expectations about the quality of a product may affect the redistribution of preferences and of capabilities across consumers when complementary, yet idiosyncratic, products emerge. The framework that is proposed here links the process of preference formation to the development of specific capabilities relative to artefacts that ensure more sophisticated ways of accessing the services. Banks are interacting with a number of consumers that are distributed across a changing degree of competence so some will be keen to experiment earlier than others. The distribution of this core of consumers has, in fact, a crucial effect in the way services are further developed for they provide feedback to banks in an experimental phase of product innovation. One interesting example is provided by the fact that within the ATM mode, there is an array of complementary services provided which has increased over time such as information retrieval and the possibility to buy credit for mobile phones. Similarly, credit cards offer today a wide range of complementary advantages linked to the mode and use of the card in selected locations or for specific kinds of purchase (Consoli, 2003). Hence, differentiation occurred in a wide degree, not only among different services but also within a specific mode of provision and the extent to which the choice of a service is subject to positive feedback depends, once again, by the degree of interrelatedness in consumption patterns.

Consider the utility function associated with a bundle of N banking commodities (eg products or services) whose level is determined by the scale of consumption activity relative to \( z_i \) weighted by the value function \( v_i \) that each individual will assign to each commodity:

\[
U = \sum z_i v_i(z_i) \quad , (i \in \mathbb{N})
\]

\[z_i = f_i [c_{i1}, c_{i2}, \ldots, c_M, c_N, t_{i1}, t_{i2}, \ldots, t_M, t_N; s_{i1}, s_{i2}, \ldots, s_M, s_N] \]

The value function \( v_i \) will depend on the distribution of all the commodities in the bundle. In particular, it is assumed here that the value of each commodity is determined by a combination of characteristics that are partially shared with other commodities (capital subscript) in the bundle and partially unique to each specific product (small subscript). Under the hypothesis of bounded rationality, the agent will not be able to know simultaneously the marginal attributes of each commodity, so the value \( v_i \) will refer to their average value (Metcalfe, 2001a). In particular, the value of the \( i-th \) commodity is determined by the costs \( c \) associated with learning how to use services.\(^5\)
a new artefact or with the process of searching for facilities in unknown areas. This in turn will depend on the time $t$ devoted to the transactions associated with the commodity, i.e. filling forms, queuing; and on the shared inputs $s$ of knowledge that are employed (eg human capital) ranging from common knowledge - i.e. recognizing the numbers, understanding the language of the instructions - to extremely idiosyncratic knowledge such as the PIN number\(^7\).

Qualitative change in this case will affect the combination of characteristics possessed by each commodity, determining a bias in the share of importance of some characteristics with respect to others as well as in the value that is assigned to each commodity. The preference towards one product instead of another is here determined by a combination of extremely individual factors, such as learning effects, together with features that are shared as being part of a group – of customers – (Kuran, 1991). The latter observation seems pertinent with the fact that complementary goods or services will entail a common knowledge base whilst retaining an idiosyncratic character with respect to some characteristic, or some combination of them (Loasby, 1998). Arguably, the mechanism of preference formation in this specific case is partially endogenized by the development of capabilities through learning mechanisms related to the costs $c$. In other words, the fact that a customer will choose one product will partially depend on his degree of dexterity with the predecessor. In this case a variation in the bundle of characteristics of the new product will determine a change in customers’ capabilities embodied in the quality variation altering endogenously, thus, the balance between the economic purpose (eg withdraw money originally) and the endowment (eg the capabilities) of the agent\(^8\) (Sen, 1985; Langlois & Cosgel, 1998).

The introduction of new products, or new ways of service provision, could be analyzed by considering the effects of cross-demand elasticities of complementary goods. Hence, instead of observing a unique demand curve, a family of negatively sloped, kinked curves could be considered when heterogeneous, yet complementary, services are introduced (HT= human teller; ATM= non-network machines; NS= network services). The degree of complementarity between co-existing products is measured here by the changing slope of the demand curves, indicating a changing elasticity to the hedonic price, when a new product is introduced. Figure two shows how the simple function of cash withdrawal has faced over time several changes and the service,

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\(^7\) Previous studies on the effects of learning from using refer to the information about product quality which can be acquired through personal experience as “pure private information” (Shapiro, 1983; Goering, 1985;1986).

\(^8\) Arguably, if increasing returns are at work, the plan of intertemporal choices made by agents will affect also habit formation and the way consumption capabilities are learned (Pollak, 1970; Becker, 1976). These considerations may be extended to consider the ramifications of these changes in consumption behaviour including the emergence or the modification of a lifestyle (Earl, 1986).
albeit unchanged in its core function, displayed several qualitative changes. The slowly changing elasticity of demand highlights the fact that, for the reasons outlined above, once a new service becomes available it will unlikely replace immediately the old one. The position and the slope of each demand curve will, thus, depend on the substitution effect which, arguably, increases as existing and new consumers become more confident with the new service provision.

FIGURE TWO ABOUT HERE

One further specification is in order at this point. When complementary services are considered the cost of creating an interface (eg the mode of service provision), which stimulates higher perceived quality in customers, depends on the ability to make access to the service at least as easy and reliable as the predecessor. The degree of specificity of a product – and thus of novelty of any successive innovation - will depend largely on how consumers perceive the difference between the old provision mode and the new one. Suppliers need to take into account that the new complementary product will partially share the function of the existing one as well as offering new features. However, if the provision of the old service (eg cash withdrawal) is perceived difficult with the new facilities, customers will keep on using old methods of access which will, thus, retain a degree of uniqueness due to its easy utilization. These considerations bring to the fore the interplay between the capability and the preferences of consumers with respect to quality improvements in the access to banking services. High costs associated with learning to use new artefacts will diminish the degree of perceived quality improvement of a new service because of a low ability to use them and, accordingly, will lower the probability of a preference towards them.

The concept of barriers to quality could be a powerful argument to explain how banks compete over quality when complementary products are introduced. The fact that given a bundle of products could compete, given their similar core function, over qualitative features such as interfacing and the degree of accessibility, puts more strain on the possibility that even within an integrated network whose components share most of the process technologies, competition and differentiation can still occur over qualitative product innovation. The results of this on the competitive structure of the activity are relevant in the sense that – as it effectively occurred in the UK banking sector – once reduced the uncertainty over process technology related costs, new entrants can effectively reap profits by introducing qualitatively competitive access to services. Here, issues related to the nature of localized innovation could account for the intra-product differentiation that some banks pursue when making decisions over qualitatively different teller machines i.e. the fact that in an intensely touristic area banks would bear the cost.
of deploying machines that allow multiple languages interface. Moreover, most contributions on barriers only account for suppliers’ production choices do not consider the important role played by consumers, particularly in consideration of how expected perceived quality affects the development of capabilities. In this case, the degree of heterogeneity of customers matters for it qualifies the niche strategy as the result of adaptive behaviour within a standardized market such as retail banking services.

5. Conclusions
The task of analysing the diffusion of innovation technologies in retail banking in the United Kingdom across the last 30 years offered the chance to overview the evolution of a system and, in particular, of the cascade of process and product innovations that followed the adoption of Information Technology in retail banking. The analysis developed in this paper offers a thorough examination of the sources and the effects of interrelatedness between complementary generations of service provision modes.

The historical account developed in the first part of this paper highlights the emergence of a technological trajectory whose pattern of development rests upon an array of complementary changes. Accordingly, it is suggested that two phenomena appear especially relevant for the structural transformation observed in the sector. First, the evolution of competition among banks, from the coexistence of early monopolies localized in geographical areas to the recent emergence of an integrated network. Second, the evolution of customers’ preferences as a result of product diversification and niche strategies pursued by banks. Neither agents nor products exist in isolation in the system and the purpose of this work has been to put forward an analysis which would delve into the way in which interdependent, mutually supporting techniques were developed within an emergent technological trajectory.
Acknowledgements
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References
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Sen, A., 1985, Commodities and capabilities, (North-Holland, Amsterdam).


<table>
<thead>
<tr>
<th>Technological events Phases</th>
<th>Service Provision External Dimension</th>
<th>Operational Function Internal Dimension</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric to Electronic Communication  (1846-1945)</td>
<td>Trade execution is reduced from six weeks to one day: security price differentials reduced; Banks emit bills of exchange and money transfers are settled through the Bankers’ Clearing House; Tabulating machines in use;</td>
<td>Coordination between the head office and the branches increases although the management of service provision is clearly divided and most front-office procedures remain unchanged; Financial Intermediaries operate through nationwide retail branches to operate on behalf of their customers;</td>
</tr>
<tr>
<td>♦ Telegraph (1846)</td>
<td>♦ Cheques in use (1850s)</td>
<td>♦ Trans-Atlantic Cable (1866)</td>
</tr>
<tr>
<td>Processors to Database  (1945-1968)</td>
<td>The Cheque Guarantee Card is introduced: the system of payment by cheques becomes more spread; The first Automated Bank Statements are printed; Central accounting units established; Money Transfer is automated: more transactions available in branches;</td>
<td>The cost of labour-intensive activities such as processing is reduced and the capacity to handle administrative tasks is enhanced; Computer applications are mostly concentrated in the back-office and operations remain centralized; Lack of specific software encourages the emergence of new professional skills;</td>
</tr>
<tr>
<td>Automated Machines and Local Networks (1968-1980)</td>
<td>The first Automatic Teller Machine is deployed in London; Branches become fully automated and services are now more easily accessible; Real time operation and control of branches are introduced; Customers can sort transactions in any branch of their own bank;</td>
<td>Several branches are opened as a complement to retail branch distribution; Financial resources are sought and new skills are developed to support the spread of ATM; Information systems provide monitoring for the bank’s management;</td>
</tr>
<tr>
<td>Integrated Network (1980-1998)</td>
<td>Gold Credit Cards offered to selected customers; Bank of Scotland introduces a banking service available through the telephone; Debit Card available to account holders; Non-payment services introduced (i.e. mortgages, pensions); Internet Banking introduced: services can be bought from virtually anywhere;</td>
<td>Number of branches reduced: the personnel is re-qualified and is given a more prominent role; Relationship Databases developed to build customer profile; LINK Interchange Network Ltd (LINK) formed as a company jointly owned by banks to expand distribution channels; Security and reliability of information processing become essential issues;</td>
</tr>
</tbody>
</table>

Table one
### Table two: average employment growth in UK retail banking 1961-1984

<table>
<thead>
<tr>
<th>Time</th>
<th>Employment growth</th>
</tr>
</thead>
<tbody>
<tr>
<td>1961-1970</td>
<td>3.5%</td>
</tr>
<tr>
<td>1971-1980</td>
<td>3.3%</td>
</tr>
<tr>
<td>1981-1984</td>
<td>2.0%</td>
</tr>
<tr>
<td>1985-1990</td>
<td>4.5%</td>
</tr>
</tbody>
</table>

### Table three: Number of branches and ATMs UK 1974-1999

<table>
<thead>
<tr>
<th>Year</th>
<th>Branches</th>
<th>ATMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>1974</td>
<td>14.908</td>
<td>N/A</td>
</tr>
<tr>
<td>1984</td>
<td>14.058</td>
<td>6.106</td>
</tr>
<tr>
<td>1989</td>
<td>13.131</td>
<td>12.253</td>
</tr>
<tr>
<td>1994</td>
<td>10.274</td>
<td>15.180</td>
</tr>
<tr>
<td>1999</td>
<td>11.044</td>
<td>17.892</td>
</tr>
</tbody>
</table>
Cumulative Effects = general purpose technology is employed in various applications

Debit Card
Online Banking
Multiservice Kiosks

Price differential
Reduction of cost of labour
More coordination between head office and branches

Speed of Communication
Automated Procedures
Cash Dispensers
Automated Teller Machines
Branches Expansion
Bank Network

Automated Money Transfer
DBMS
Real time operations
Full Automation of branches
Switch system

Magnetic Stripe
Microchip

Phone Banking

Branches Reduction

Internet

Early Adoption (1846-1945)
Specific Application (1945-1968)
Emergence (1968-1980)
Diffusion (1980-1998)

Transformation Effects = specific applications are implemented in new frameworks generating new skills and new applications

Figure one
New technology eg new mode of service provision becomes in use. Initially it is very substitutable and very elastic to price changes.

Consumers may switch to the other technology so the incumbent technology becomes more substitutable eg less elastic to price changes.

Figure two