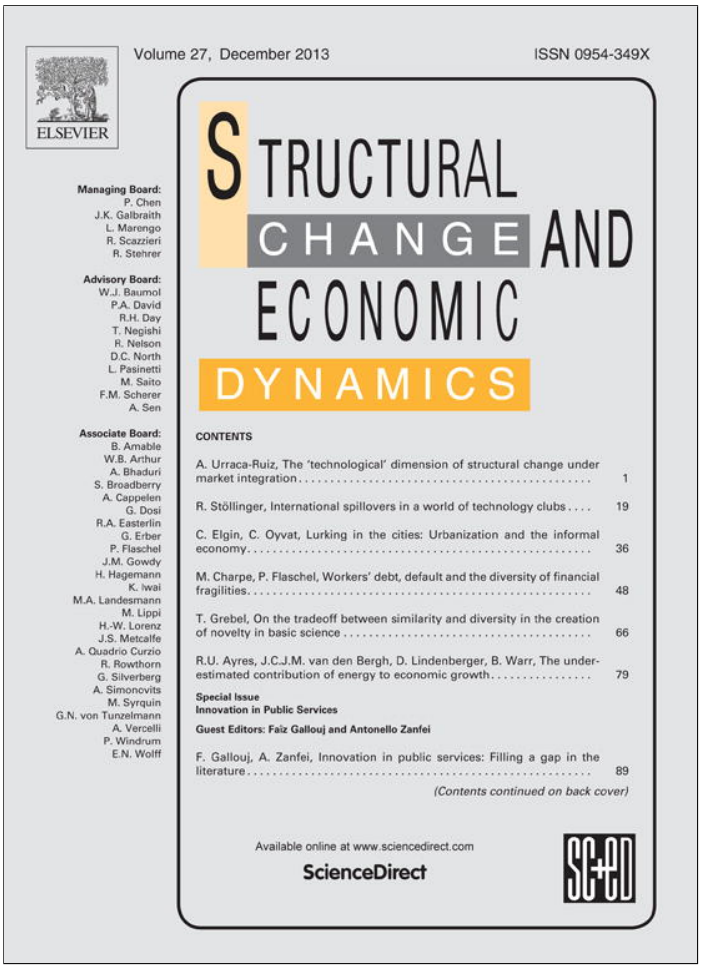

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Service output, innovation and productivity: A time-based conceptual framework☆,☆☆

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ABSTRACT

The paper adds to the literature on innovation and productivity in services in a three-fold way. First, it extends recent literature attempting to reconceptualise service output in terms of Lancasterian characteristics. Our focus is the analysis of inputs involving the use of client (customer) time in co-production and informational inputs, which may be produced by either the service provider or the client. In particular, we focus on those features that are associated with the use of information and communication technology (ICT) in service definition and delivery. Second, it models user choices in terms of the time-allocation between self-production, co-production and purchase as influenced by competences and time-saving preferences, and supplier choices as governed by opportunities to benefit from informational economies, cost saving arising from the stimulation of co-production and productivity increasing opportunities arising from the use of ICT. Third, it uses the conceptual framework to re-interpret the well-known theory of innovation in services, the Barras reverse product cycle model. Implications of the model for productivity are also considered. Finally, the model is used to interpret UK experience with e-government service: NHS Direct and Direct-Gov. The paper concludes with a research agenda for the scholars of innovation in services.

1. Introduction

In order for advances to be made in the study of service sector innovation, better theoretical conceptions of service 'production' processes, service outputs, and service productivity are needed. The existing literature has explored several different directions departing from Adam Smith's dismissive view of these issues.[3]

Smith's view is entangled with the classical distinction between productive and unproductive labour, which persisted until the neo-classical period during which the labour theory of value was largely extinguished – largely, but not entirely. Theories of value and definition of output are intrinsically related. Utility theory of value is in principle better equipped than the labour theory of value to explain value creation when the output of the production process is immaterial. A key feature of the labour theory

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[3] "Unproductive labour does not fix or realise itself in any particular subject or vendible commodity. His services generally perish in the very instant of their performance, and seldom leave any trace of value behind them, for which an equal quantity of services could afterwards be procured" (Smith, 1960 [1776]: Book II, first para. of Ch. III).

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of value, which lingers is the conceptualisation of national income and product accounts as a record of physical output – the expansion or contraction of the production of bales of cotton or tonnes of steel over time.

Many of the mis-measurement issues and biases highlighted by the literature on the economics of services and innovation in services[4] over the past decades stem from the lack of a proper definition of service outputs, whose immateriality makes it difficult to find a unit of account to aid in separating monetary value from the 'quantity' of services produced.[5] This has affected conceptualisation and measurement of productivity and has hampered a proper reflection on the economic effects of technological innovation in services.

A new foundation of the theory of value, which is better able to account for the immateriality of output and the mechanisms behind productivity improvements, is desirable. A promising avenue in this direction would build on Georgescu-Roegen's time-based representation of production processes. This is more ambitious task than carried out here[6]; instead we take a substantial step towards a redefinition of service output and productivity and a reconceptualisation of innovation in services – based on an extension of Lancasterian consumer theory.

Throughout this paper we will be using the term innovation to indicate implement novelty, which includes the more common definition of innovation as commercialised invention, but also extends this definition to organisational change and to novelties in inputs, processes and outcomes that are only indirectly and implicitly monetised due to the value of time.

There are two practical reasons for pursuing a Lancasterian approach. First, it may be observed that a specific immaterial feature of many services that is growing in importance is their information content. For example, in retailing, growing information on the qualities of physical goods including their provenance, composition, and application, as well as other users' experience has important effects on consumer choice.[7] Second, it is an obvious, but nonetheless striking feature of contemporary life, that the technologies for information distribution, Internet access and search services as well as the devices used to access these services are ubiquitous and are being used more intensively over time. Hence, our premise is that the provision of information and the means to access it should, in a contemporary context, be central features in our understanding of how service outputs are defined and measured. In more theoretical terms, the informational and information access characteristics of services (and goods) not only need to be taken into account, but a means for examining the substitution, complementarity, and quality implications of these characteristics is needed.

To address these issues, we examine the foundations of service production along the lines suggested by Lancaster (1966a,b) and by Gallouj and Weinstein (1997) and Gallouj and Savona (2009) who reprise and extend the Lancasterian approach to defining output. According to the characteristics-based approach in its original formulation (Lancaster, 1966a,b) and in those which followed Saviotti and Metcalfe (1984), Gallouj and Weinstein (1997), Gadrey (2000); De Vries (2006) and Gallouj and Savona (2009), output is represented by a set of vectors of characteristics and competences, which are linked to each other. Vectors of characteristics include technical ones, service ones (or, interestingly, 'final users' value') and competences, both those of suppliers and users.

The presence of users' characteristics in the representation of service product serves the purpose of overcoming one of the major shortcomings of the existing theory of service 'production' and innovation, that is the separation and dichotomisation of production and consumption. In fact, many, if not most, services rely upon co-production between producers and users (i.e. co-terminality between delivery and consumption (for reviews, see De Vries (2006) and Gallouj and Savona (2009, 2010). Moreover, the economic significance of services most arises from their being multi-attribute. The significance of co-production and the interactions between co-production and the multi-attribute nature of most services suggests the need for a different approach to assessing the 'supply' and 'demand' of services, than treating them as ordinary commodities with a price-quality offering that triggers a purchase depending upon consumer tastes and incomes. This is of particular significance for those services that entail information as an important attribute, where co-production involves information exchange and where there are substitution and complementarity relationships between the information provided by suppliers or users or both in the course of choosing and delivering services. In other words, defining attributes of many (but not all) services are informational.

The Lancasterian framework therefore offers an interesting conceptual platform, which allows advance in both the definition of service output and the analysis of the effects of technical change. It allows including the role of customers in the *innovation process* – this latter having been claimed to be more important in services than in other sectors, again due to the co-terminality between delivery and consumption. Also, and most importantly for the purpose of this paper, looking at an output in terms of characteristics and competences allows us going beyond the market and non-market contexts in which outputs may be delivered to consumers, and extension of the conceptual framework to the domain of public services.

For this purpose, we examine how some of the features of production processes are illustrated in the UK e-government context using two major online sites – NHS

[4] A literature in which Griliches (1992) is central, see also Gallouj and Savona (2009) for a review of these issues.

[5] Traditionally, the issue of service production continues to reflect the generalisation that services are produced by labour intensive processes with few opportunities for productivity improvement and fewer opportunities for achieving economies of scale.

[6] We do not deal here with the recent revisions of production theory linked to time representation (for a recent and exhaustive review, see Vittucci-Marzetti, 2013).

[7] For example, it is blurring the boundaries between search goods (defined as goods whose qualities are common knowledge) and experience goods (those goods requiring experience to ascertain qualities), a development that may facilitate product differentiation (Klein, 1998, #1332), (Huang et al., 2009, #1331). However, it is not simply the case that more information is better. In food retailing, for example, (Grunert, 2005, #1333) concludes 'more information may not only be without effect, but may in some cases increase confusion and consumer concerns.'

Direct and DirectGov. Both of these service offerings are major portals for citizen access to government services which exhibit the Lancasterian elements discussed in this paper as well as the features of incremental and combinatorial innovation illustrated in Gallouj and Weinstein (1997) or De Vries (2006, #1181) and modularisation as developed by Sundbo (1994). The results are analytical rather than quantitative estimates of output or productivity. In particular, we will consider how the choice of supplied service characteristics is reflected in three features of the service production/consumption relationship: (1) co-production, (2) user capabilities, and (3) the expansible nature of information.

In addition, we indicate how the Barras reverse product cycle (Barras, 1986, 1990), a model often employed in assessing technological change in services, may create a misleading guide for managerial action in the case of e-government services and a series of mis-alignments in policy. This line of argument is based on the observation that many e-government software applications embody Barras' assumptions and deliver a particular 'solution' that will meet a particular set of user needs. We then consider how solutions derived from the Barras model may result in shortcomings in the supply and utilisation of services.

The remaining of the paper is structured as follows: we reprise (Section 2) and extend (Section 3) the Lancasterian model of output characteristics. Our model of service innovation considers how productivity in services may increase opportunities in services provision through informatisation and different degrees of co-production. Section 4 locates the contribution of the present paper in terms of conceptual advance with respect to Barras' Reverse Product Cycle model. Section 5 briefly draws implications in terms of conceptualisation and measurement of productivity increases linked to time-saving innovation. Section 6 applies our conceptual framework to the domain of public services and briefly discusses examples of innovative development of two e-government services, NHS direct and DirectGov. Section 7 concludes.

2. The Lancaster model and a proposed extensions

Lancaster's definition of product, developed from Gorman (1959) and originally conceived within the framework of consumer theory (Lancaster, 1966a,b) has been reprised by Saviotti and Metcalfe (1984) for manufactured products and adapted by Gallouj and Weinstein (1997) to account for intangible products (see Gallouj and Savona, 2009, 2010 for a review).

Briefly, as illustrated in Fig. 1 (from Gallouj and Savona, 2010), a product/service may be 'decomposed' in a series of vectors of characteristics. Both service supplier and consumer are represented here, each of them contributing to the output representation by embedding both technical and competence characteristics.

The final (utility) characteristics are derived from the interaction of both clients' and providers' technical characteristics and from the interactions between client and supplier competences. The aim of this representation is to highlight the association between combined external characteristics (i.e. the technical ones) and the internal ones (i.e. the competences) in defining the final output characteristics. However, in this version, the Lancasterian representation of the service as a vector of 'input' and 'final' characteristics is blind with respect to the degree and the *choices* of co-production between consumer and producer. This omission is particularly of concern when the information attributes of a service are co-produced because of the substitution and complementarity relationships that are possible. These represent the innovation potential of service delivery. For example, it may be possible to employ user informational inputs to simplify the delivery of a service at considerable saving to the producer. The producer may then pass on all or part of these savings to the client, perhaps depending on the competitive conditions of the market in which the service is offered. Since the principal cost of the co-production of the information attributes involves a re-allocation of the time employed in defining and delivering the service between producer and client, it

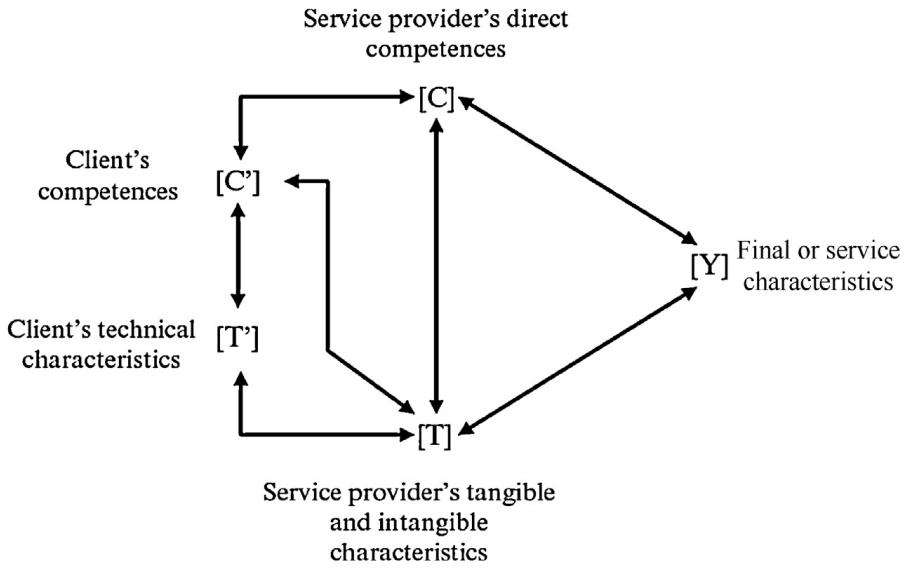

Fig. 1. Source: Gallouj and Savona (2010) – adapted from Gallouj and Weinstein (1997) and De Vries (2006).

is necessary to extend the attributes and capabilities framework to include this temporal component.

We propose here an adaptation of the Lancasterian approach to (service) output representation. This consists of introducing two further vectors of characteristics, related to both provider and consumer. The new vectors allow us to represent the choice/trade-off that consumer and supplier face among different degrees of co-production; further, it allows us to explicitly introduce technical change and its effects on *both sides* of product representation. These are the *time and information vectors*.

As will be detailed below, the *time* vector serves as a conceptual bridge between the combination of user and supplier's competences and the extent of co-production to get the final product's characteristics.[8] Depending on (i) the degree of her competences, (ii) her tastes, (iii) the degree of access to technical and informational support, (iv) her time-saving preferences, the user will choose whether or not to complement her competences with those of the supplier to co-produce the service. The choice of co-producing will depend therefore on the amount of time the co-production will save her with respect to the two "extremes" of the continuum, i.e. choosing between an exclusive self-production – relying entirely on her own competences – or a total outsourcing of the service – i.e. relying entirely on the supplier's competences. The vectors of time and information characteristics embedded in a particular service – where the information vector couples with the (generic) technical characteristics of the service[9] – serve to define the amount of time uniquely associated to one particular consumer, which is embedded in her own degree of competences, and the unique degree of co-production chosen by the consumer.

This process is mirrored in the choices available to the service supplier. The extent to which the service provider allows for co-production will depend on (i) the degree of his competences, (ii) the (sunk) costs of technical and informational characteristics and (iii) the time-saving impact of the co-production, which in turn will depend on the customer's competences.

At this stage we are aware that the time characteristics of the service might well be 'embodied' in the competences and production inputs represented by the technical and informational content of the service. However, our intent is precisely to unpack the time content associated to each single consumer and supplier characteristics to highlight that the choice process – on both sides – substantially depends on the time-saving results of the co-production. The level of co-production is unique to each consumer and is the result of a 'convergence' phenomenon between provider and consumer time-saving preferences.

Time is therefore entering the characteristics-based service representation as a multi-dimensional element: as a flow-production input (a la Georgescu-Rogen, see Vittucci-Marzetti, 2013 for a critical review); as a 'stock' production input for competence-building purposes; as a constraint which shapes both producer and consumer time-saving preferences.

The modified Lancasterian representation of the service output proposed here allows the examination of innovation in services as a time-saving process resulting from the (changing degree of) co-production of service provider and consumer. We argue (and detail in Section 4) that this model goes beyond Barras' reverse product cycle in explaining the focus of innovative effort. We relate this to empirical examples in the domain of public services.

3. A time-based model of innovation in services

3.1. Baseline model of service consumer choice

We begin with a baseline model that incorporates the possibility of co-production and also makes clear the nature of the trade-off between different levels of self-production and the role of service suppliers. We then extend the baseline model to a multi-attribute service where some of the attributes are better suited to self-production and others to service out-sourcing to the supplier.

We define an arbitrary service as unit of consumption for which an individual consumer is willing to allocate a vector of time and money. Given the prosaic but economically accurate observation that 'time is money' (a consumer may generate money through the use of time devoted to wage income to substitute for time in service production,[10] the vector of time and money can be collapsed to a single vector of time.[11] Allocation of time over the planning horizon of the service 'consumer' can be portrayed as a vector of allocations of time over intervals, each of which is bounded by the length of the interval chosen. Hence:

$$D_{ij} = U * (T)$$

where:

D_{ij} is the amount of demanded[12] service j by consumer i resulting from a utility maximising choice of time allocation, U^*, which is influenced by the user's capabilities.

$T = t(k)$, $k = 0, \ldots, H$, H being an individual's planning horizon.

The elements of T, $t(k)$ include the amount of time allocated for:

[8] Separating out time from other attributes is an arbitrary choice in the representation of the model, which serves to highlight the role of time expended by producers and clients. As in other models of productivity improving innovation, we neglect the possible externalities and adjustment costs in favour of a narrower comparative statics approach. It is assumed that the externalities and adjustment costs of innovation are either resolved through the annealing processes of competition or are internalised to the actor making the change (and hence accounted of in the decision to make the innovation).

[9] We reprise (Gallouj and Weinstein, 1997) and focus on the informational capital involved in service delivery.

[10] Excluded from the current problem setting are prior endowments of monetary wealth that could be applied to the purchase of services.

[11] The problem in doing this is that this collapse erases the 'objectivity' of time; different consumers will have different valuation of time and hence different utilities associated with time saving.

[12] As mentioned above, consumers choose to self-produce entirely (in this respect they supply their own service), to purchase entirely (they demand services to the supplier) or to variously co-produce. Self- and co-production, together with the purchasing case, all depend on the amount of (finite) time allocated to work/leisure.

a) the 'consumption' of a service
b) the co-production of the service, and
c) the earning of wage income to pay for purchased service.

Summing these individual demands for purchased services will create a market demand for them, i.e. $D_j = \sum_i D_{ij}$.

The price of services, which influences the trade-off between the consumption of the service and also the extent of co-production, is a latent variable in this formulation. Because each configuration of possible service offerings involves different possible responses by users, it will be extraordinarily difficult either for this market to be in equilibrium or for producers to optimise their selection of service characteristics (more on this later). In effect, each supplier must choose a portfolio of service offerings and discover the price that the market will bear for these services, essentially discovering 'willingness to pay' by making offers and gauging the response to them. In a simplified way we can portray each these 'offerings' as involving a constant returns to scale production process.

$$S_{ij} = Q_{ij}(K, L)$$

The summation over j will be the total portfolio of services offered by the service supplier firm i. Holding j fixed the total supply of services of that type will be a summation over i.

Viewed in this way, the primary factor differentiating services is demand response. In this simplified model, production is taken to be unspecialised, reflected by not indexing capital (K) and labour (L). In general however a proportional increase in S_{ij} will require a proportionate increase in K and L (the constant returns feature). Whether a particular firm will be able to earn positive profits will depend upon the take up of their service offerings at the price at which they are offered which will depend on individual firm productivity (which will also reflect their capabilities) and that of their rivals. In other words the relation between D_j and S_i is not easily mediated by a price, primarily because of the multitude of possible changes in consumer and producer capabilities (including changes in these capabilities resulting from experience), variety of competitive alternatives, and user preferences for allocation of time.

This baseline model serves the limited objective of highlighting the trade-off confronting the user with regard to devoting the time needed in wage labour to pay for a service rather than self-producing it and the complexities this creates for suppliers. Many possible allocations of time can be imagined, some of which involve zero acquisition of services because it is time saving for the consumer to self-produce rather than purchase a service. Others involve allocating positive amounts of time to both the wage labour needed to pay for the service and to time engaged in co-producing the service. Each service may involve different levels of time in co-production and these levels may also be influenced by consumer capabilities (i.e. co-production time will vary according these consumer capabilities). In general, it may be expected that the purchase of a service will always involve a positive amount of time in 'co-production', if nothing else, because the consumption of the service will take time.[13]

Thus, for a simple example, a person may have a haircut at a barber or hair stylist which will always involve a positive amount of user time input – one part generating the money to pay for it and a small consumption element for receiving the haircut.[14] It is also possible for an individual to self-produce the haircut, i.e. to substitute the time needed in wage work to pay for the haircut with a time needed to self-produce and consume the haircut. It may also be possible for the individual to co-produce part of the service by a final trimming or shaping of the haircut to desired detail. Of course, the quality of these alternatives may be different – however, this is also mostly a matter of time and consumer capabilities. Given sufficient time (and ingenuity), an individual can be assumed to be able to replicate the quality of the purchased service with own production or, alternatively, the individual may barter their time with someone else's to engage in reciprocal 'self'-production.

This simple model offers very little scope for decision making by the supplier. Because of the complexity of the consumer choice, it will be difficult to anticipate response to the combination of service attributes and price and the supplier must essentially iteratively experiment to discover a viable market position.

Whilst internalising the price of the service as a choice of time allocation is unconventional, it serves the useful purpose of making the trade-off between service consumption choices and time allocation more directly comparable. It also establishes the basis for the extension offered in the next section, which introduces the complete model.

3.2. The complete model

Whilst the previous section focussed solely on the consumer choice problem regarding alternative service provisions, the primary aim of this paper is to examine service supply from the producer viewpoint. How might producers achieve better (and hence more desired) and more productive (and hence less expensive to produce) service offerings? If we take into account co-production, it is possible that a service might achieve both aims by design of those features that elicit the desired level of co-production. In other words, co-production can be considered as a saving from the cost of an entirely supplier delivered service and hence a net benefit. Co-production may allow the user to economise on wage labour in the production of the service (in effect, sharing the reduction in costs of delivering the service with the producer) and may support an

[13] It is somewhat difficult to construct examples of services that require zero time to consume. However, the purchase of some services involves 'contingent' allocation of time, i.e. it is only under certain conditions that time is required to consume the service. An example is insurance. Once signed up, the insured consumer will only have to allocate time to paying for the service unless a claim is made (and in the special case of life insurance, co-production by the insured customer will be neither possible nor necessary).

[14] A co-production element for haircuts (e.g. sweeping up) is not inconceivable, but is not common practice. The possibility of changing the nature of the service to allow a greater element of co-production is considered further below.

improvement in the quality of the delivered service (e.g. self-service ATMs available 7/24 versus bank clerks available only during banker hours).

Demand

$$D_j = U^*(T_{CP}, T_{CB}, T_W)$$

where D_j is the demand for services expressed as the utility maximising allocation of the time devoted to co-production T_{CP}, creating capabilities T_{CB}, and wage labour T_W.

In other words, the acquisition of services is taken to be the result of a utility maximising choice of time allocation as in the simple model, with the addition of time used to construct capabilities. In this version, we have collapsed the time needed to consume the service as a component of T_{CP} (the co-production time).

Supply

The supplier faces the same problem as in the baseline model of not being able to determine how customers will respond to specific service attributes. However, in this complete model, we wish to consider two types of choice that the supplier might make: the 'co-production potential' and the degree of 'informatisation' of each possible service offering.

To represent these possibilities we will segregate factor inputs by these two facts so that the firm i is able to produce a collection of services j with different levels of these two factors

$$S_{ij} = Q_{ij}(K_I, K_{CP}, K_O, L_I, L_{CP}, L_O)$$

where the subscripts represent the levels of inputs associated with the informational (I), co-production (CP), and other (O) characteristics of the service. The idea here is that:

$$\frac{\partial S_{ij}}{\partial K_I} > \frac{\partial S_{ij}}{\partial K_{CP}} > \frac{\partial S_{ij}}{\partial K_O} \quad \text{and} \quad \frac{\partial S_{ij}}{\partial L_I} > \frac{\partial S_{ij}}{\partial L_{CP}} > \frac{\partial S_{ij}}{\partial L_O} \quad \forall i, j$$

This is a strong assumption. However, it is the claim that informational capital (and labour) has higher marginal product than capital (and labour) associated with co-production and the marginal product of capital (and labour) associated with co-production is higher than that associated with other or conventional service delivery. Informational capital may also influence the marginal productivity of co-production. However, this problem can be addressed through definition, informational capital being partially a 'pure' contribution to supplier and another portion of informational capital being allocated to co-production capital.

In other words, the design of a service bears with an implicit allocation of capital and labour inputs, which can be related to the extent of informatisation provided by the supplier and the effort to elicit co-production by the user. Whether either of these will be successful in stimulating demand for the service or whether the user will take up the co-production opportunities offered is, from the supplier's viewpoint, uncertain. However, in order for these possibilities to exist, allocations must be made to them and the strong assumption regarding marginal products associated with each of the factors is that amount of service offered is more responsive to investments related to co-production and informatisation than it is to conventional inputs of capital and labour.

Ceteris paribus, this means that suppliers have an incentive to move from conventional service delivery (i.e. where $K_I = K_{CP} = L_I = L_{CP} = 0$) to service delivery involving co-production and informatisation (i.e. positive values of these variables) assuming (a) that the costs of a unit of each of these types of capital is commensurate and (b) that service offerings involving co-production and informatisation are near substitutes for those involving more conventional service delivery inputs.[15]

Obviously, this cannot be done for all services – providing information about haircuts does not help very much in actually accomplishing that particular service.

3.3. Features of the time-based model within Lancaster's framework

A feature of this model that is more specific to e-services (especially those provided by government) is in the method of service delivery. E-services involve a mixture of information provision, support for transactions (including queries) and other interactions (both interpersonal and automated). The extent to which these elements can be provided using automated information systems as opposed to direct human intervention will be an important influence on the productivity of service delivery. In general, the greater the level of human intervention, the more service delivery will be subject to constant returns to scale. Conversely, the greater the automation, the more opportunities there will be for increasing returns to scale. The difference arises from the basic features of information as an economic good – the very low costs of information reproduction (information expansibility) and the potential for low costs in automated information retrieval (information processing economies) create a potential for economies of scale.

Of course, both of these opportunities – for improving the attractiveness of services and for reaping benefits of automated systems – will also depend upon producer and customer capabilities. It would be somewhat blasé to assert that there are always opportunities to create more desired co-production and more efficient 'informatised' (taking advantage of increasing returns to scale in information distribution and processing) e-services. Capabilities introduce an investment element for both consumers and producers. From the viewpoint of consumers, this can be seen as a further allocation of their time. From the supplier viewpoint, this can be viewed as a standard investment problem in intangible capital.

[15] This latter assumption is also a strong assumption. However, if it is not justified, then attempts to offer such services will not be taken up and hence will not be offered in some future iteration of the package of offerings.

There are some problematic elements of this model. It is a satisficing rather than an equilibrium model. Although the producer can perceive opportunities to improve productivity (reduce costs), there is uncertainty surrounding the take up of service offerings involving higher levels of informatisation and co-production because of the complexities of user response. We partially gloss over these problems by using the assumption that some services, having these features (informatisation and co-production), can be produced that are close substitutes for services delivered more conventionally and hence, because they can be produced more cheaply, the producer's incentives are clear and unidirectional (ceteris paribus, demand curves may still be assumed to have downward slopes). Nonetheless, every user is likely to have different capabilities and preferences with regard to both co-production and informatisation and thus producers have to search rather blindly for characteristics that elicit greater customer response (from which competitive advantage through growth are possible because of the amplifying feature of information economies).

Despite this analytical shortcoming, this model has some realistic features. Service suppliers often begin with a market in which they have some experience, from which they try to enlarge their client base and, in so doing, adjust their service offering. This process often involves considering ways to deliver services more efficiently such as investment in intangible resources (databases for customer relations management or customised service offerings) or ways to reduce costs of service delivery (by dis-intermediating some of the labour they employ and encouraging clients to co-produce the service).

This perspective on the nature of service provision isolates two important features in which it is fairly straightforward to see how supplied service characteristics and user preferences interact. However, these elements are not the only ones that might be considered within a similar framework. For example, it is possible to further consider the process of co-production as a collective activity rather than exclusively accomplished by individuals and through this mechanism to create further opportunities for service providers to facilitating and intermediating services.[16] Similarly, it is possible to conceive of a more articulated vertical structure of service production in which elements of the final packaged service are produced by more specialised suppliers. These additional extensions, not developed further here as a matter of theory, suggest further problems of co-ordination and common purpose.

In summary, in adapting the Lancasterian framework to the nature of service production and consumption we recognise, but treat as a background issue, the idea that a commodity is a multi-attribute artefact in which individual consumers have complex preferences for individual characteristics and bundles of characteristics. We emphasise, however, the relevance of a Lancasterian theory of production in which elements of common infrastructure (information) and co-production as well as the possibilities for collective production and specialised service production help to explain the evolution of service markets that allow these features and provides new tools to conceptualise innovation in services.

We now turn from this abstract discussion to a series of more applied observations. First, we consider producer opportunities for expanding informatisation and co-production. Then in Section 4 we examine how this theory can be related to Barras's (1986) theory of the reverse product cycle of service innovation in order to suggest how this model encompasses key features of the theory we have developed whilst also missing important implications and alternatives. This followed in Section 5 by a short examination of the implications of this framework for examining service productivity and in Section 6 by very concrete observations about the nature of two leading UK e-government services.

3.3.1. Opportunities to expand informatisation

The uncertainties regarding demand make it difficult to disentangle whether greater productivity follows from higher levels of information or co-production-related capital (and labour), particularly for individual service providers. On the one hand, for a particular supplier, informatisation may prove very profitable if substantial demand arises for such a service because the intangible informational capital allows a very low marginal cost of serving an additional client (or at least the absence of a need to expand labour inputs proportionately with increases in service). On the other hand, if the large fixed costs of creating this intangible capital are not born by a substantial client base, i.e. there is not a strong take-up of these services, it will not be possible to recover them and the service provider will earn a loss. Thus, any particular supplier may choose informational capital investments that are actually inimical to their success rather than a source of advantage.

Among the choices that service suppliers have for investments in intangible (informational) capital, there are several different possibilities that may be described in generic terms. Each of these possibilities may be understood as innovations in relation to conventional service delivery methods. We consider three of these. First, there is the possibility of creating a customised or one-off system designed specifically to the characteristics and routines of the service supplier organisation. This type of investment, if successful, will provide a highly differentiated service offering which customers regard as offering substantial improvement in the quality of the service whilst simultaneously reducing the labour necessary to service the expanding client base. There are two risks associated with this choice – one is that such customised informational capital is likely to be relatively expensive (risking not acquiring a large client base) and the other is that projects to develop and deploy such capital are, themselves, relatively risky (possibly producing non-recoverable investment costs).

A second alternative often available to service providers is to acquire a standardised vertical application (or sector specialised system). An example of such systems are these produced by Enterprise Resource Planning (ERP) system companies such as SAP, Oracle, Microsoft, or other large software companies. The advantages of such systems are

[16] This is one way to interpret the growing role of virtual communities and social network infrastructure providers.

that their cost of ownership (cost of acquisition, maintenance and use) are likely lower than the development of a customised system and they have lower development risks and costs. The disadvantage of employing a standardised system is that it provides fewer opportunities for service differentiation and innovation – what can be done is often constrained by the architecture or design of the system.

Whilst the first two possibilities emphasise the service delivery process, both are supported by the creation of service and customer related databases, i.e. information that can be queried, re-packaged, and customised in the process of service delivery. The creation of rich and varied data sets that are relevant to fulfilling customer service needs is potentially a form of knowledge codification that substitutes for 'know what,' 'know who' and 'know how' type knowledge that might otherwise be mastered by human service workers. The potentials for such database innovations to contribute to perceived improvements in service quality (and hence greater take-up of a service offering) are often over-estimated, but sometimes very successful in encouraging the use of informatised systems, regardless of whether they are built on a customised or standardised platform.

These different approaches to creating informational capital are meant to be illustrative and to highlight the complexity of the strategic choices that service providers face. Some indication of the relative success of standardised platforms is indicated by the major growth of the companies providing such solutions software over the past several decades. The result of the articulation of this market is that few types of business lack these options for increasing the informational capital and labour associated with service delivery, a feature that we will consider in relation to the Barras reverse product cycle model and e-government services below in Sections 4 and 5.

3.3.2. Opportunities to expand co-production

The methods and outcomes of allocating capital and labour to expanding co-production, which also represent innovations on conventional techniques for service definition and delivery, offer opportunities that are more complex and less generalisable. As Gershuny (1978) and Gershuny and Miles (1983) have observed, this supplier choice may come in many forms and some types of co-production are arguably much more efficient than supplying the service to the client – e.g. a service client's filling in a form is likely to significantly more efficient than paying a person to verbally interrogate the client in order to fill in or enter data online. Still greater efficiencies are possible if the client enters the data online.[17] In this process, both the nature of systems and user capabilities are of some significance. For example, information may be retained for a returning customer, requiring that they only update information as their circumstances change, a system feature. In addition, and outside of the supplier's decisions, the client's computer system may retain the type of information needed to fill in forms.

This simple example illustrates a general property of co-production of e-services. What is involved is often 'shared information' – information retained by the service supplier but contributed by the user. Opportunities to build such shared resources are particularly prevalent in online media e-commerce applications such as Amazon and iTunes where users' prior purchase decisions and searches are retained as guides to their possible interests.[18] In this case, the sharing of data by the user is largely inadvertent and this has raised concerns about user control and privacy. Nonetheless, from the producer's viewpoint this information is co-produced and finding such market and marketing related data by other means would likely be much more expensive.

In the case of e-government services, co-production is complicated by the user control and privacy issues. Individuals may be more concerned about the retention of individual information by government than private enterprise. Nonetheless, the use of e-government resources does provide opportunities to benefit from co-production processes simply because patterns of use become predictive – what a particular user seeks in a particular online session during which their individuality if not their identity can be retained provides a prediction as to areas in which they might be interested and, with sufficient additional investment and experience, this online behaviour can be used to improve and customise the delivery of services.

3.4. Summary

In summary, the demand side of the model emphasises the role of co-production in the choice of service and the risk reduction as a motive for consumer choice. This is addressed by the 'branding' of services, which is presumed to carry some weight in terms of signalling the feasibility and lower costs of a service. Beyond this, the client is taken to have some latitude in engaging in co-production for which it might be expected that they will share some of the resulting cost savings with service supplier. The possibility of self-production of services is clearly present and reflects a potential client's evaluation of alternative choice with regard to the allocation of time to consume, co-produce or self-produce services. Many services, but by no means all, services may be self-supplied. In general, however, potential clients will be better off allocating additional time to wage services to pay for rather than self-produce some services. Adapting these precepts to the case of business services would involve substituting outsourced service labour for internally employed labour, the latter being roughly comparable to self-produced service. Finally, on the demand side, it is reasonable to assume that there are interactions between the informatisation and co-production characteristics of specific services.

[17] Incidentally, this latter possibility is a plausible explanation for the delay in productivity gains from the personal computer revolution of the 1980s. In effect, direct data entry dis-intermediates other relatively costly forms of data capture but does not become available until individuals are online (i.e. post 1995 in many of the OECD countries).

[18] See also Lehrer et al. (2012) for a qualitative analysis of the co-production in business services.

On the supply side, we have emphasised the possibility of choosing to 'informatise' services where possible as this offers possibilities to reduce the marginal costs of production and, if a threshold level of demand is forthcoming, economies of scale resulting from distributing the initial costs of production of informational capital (K_I) where the opportunities associated with ICT that allow low marginal costs of reproduction, either by standardising a service or by producing a system that is able to deliver services customised on an 'as needed' basis. It was also noted that the service provider might choose various levels of co-production opportunity but that the take up of this would generally be beyond the a priori knowledge of the service provider. We also have stated the supply function without restriction to possible interactions among the variables and made price a choice variable with assumption that the producer does not have perfect information about the take up of service offerings – partly due to the uncertainties surrounding client willingness and ability to co-produce the service.

This model has a number of direct implications and can be fruitfully extended to consider expectations or ideas about the process of service innovation, the subject of the next section, productivity (Section 5) and the political economic forces governing the implementation of e-government services (Section 6).

4. Departing from Barras' 'Reverse Product cycle' model?

On the basis of our re-examination of the Lancasterian characteristics-based service representation – proposed in Section 2 – and its extension to the time-allocation based model of innovation in services – proposed in the above Section 3 – we discuss in what follows how our conceptualisation of the service product and service innovation both reproduces and departs from the Barras model. Such a discussion is a useful way to grasp the managerial implications of this approach to public services.

4.1. The original framework

Barras (1986, 1990) borrowed and adapted the product life cycle framework from Abernathy and Utterback (1975, 1978) to develop a dynamic model of innovation which could function for services. With the Reverse Product Cycle (RPC) Model, Barras argues that ICTs represent an "enabling technology" (Barras, 1990: 215) for service applications. Three evolving stages, depending on the degree of ICT adoption, are identified: incremental process innovation, radical process innovation and, finally, product innovation, where a service innovation represents somewhat a 'radical process innovation'. These stages reveal the existence of a learning curve behind the adoption process (Barras, 1990: 226).

The incremental process stage is a typical 'supplier dominated' phase, aimed at increasing efficiency. The second stage implies an upgrading of the learning-by-doing process, where a certain degree of radical departure characterises service innovation, which are aimed at quality rather than efficiency changes, though still through a process of selective standardisation. The third stage – according to Barras – is typically 'user dominated': the introduction of the radical service innovation is considered as follows: "the more radical the service innovations become, the more reasonable it is to identify the resultant improvements in service delivery as new services" (Barras, 1990: 226).

4.2. Is Barras RPC model empirically generalisable?

The theory of service innovation developed by Barras (1986) is well-known and is consistent with the idea that there is a systematic bias in favour of more generalised models which are then refined and developed in application. The idea that this creates a 'reverse product cycle' Barras's (1986) term in services is somewhat less persuasive as a *theoretical* generalisation; regardless of whether a service firm starts from a customised or a generalised design, development effort is required. However, the use 'reverse product cycle' as an *empirical* generalisation was prescient and has accurately characterised the dominant trend in the last quarter century of software development for services. This is remarkable and somewhat ironic given the very modest level of development of ICT at the time of (Barras, 1986), prior to extensive diffusion of personal computers, public access to the Internet, or the range of online services that have subsequently emerged. Despite technical progress, the model remains an effective tool for service innovation in part because it is closely linked with developments in software management including a preference for COTS (commercial of the shelf) software and the contemporary development of 'cloud based' information services which create contemporary versions of the 'enabling technology' that was central to Barras' argument.[19]

The success of the reverse product cycle model as an empirical generalisation may, however, create a hazard. One would expect that in several decades those applications that were most suitable and feasible for this form of the development had been exploited. As application domains in which the reverse product cycle model may be less suitable, i.e. where the alternative model of producing a proliferation of customised and idiosyncratic approaches to defining and delivering services would offer greater opportunities for advance in client use and innovation.

A signal that this might be the situation in a specific sector would be evaluations that such systems were not meeting user needs or were failing to be taken up. This does not mean, however, that the alternative of more customised systems would necessarily be better. It might be that certain application domains are, with current software engineering techniques, user characteristics and preferences, and service provider capabilities, infeasible for 'informatisation' (the development of large scale intangible

[19] Cloud-based services are a particularly good example of the power of reverse product cycle type development with generalised applications potentially serving a global client market (at least among those global countries with adequate Internet infrastructure to support concurrent communication and hence terminal based interaction with the online applications).

(informational) capital (K_I) in the model above).[20] In such domains, service providers may have little alternative than the constant returns technology associated with haircuts and other forms of direct service.

A further barrier to progress in 'informatisation' may be the characteristics of users. Whilst co-production may be relatively straightforward for some of the activities previously discussed such as the filling of forms or conduct of ordinary online e-commerce transactions, requiring more sophisticated co-production capabilities of the client may create an unfavourable assessment of the time that they would require in co-production to learn to use or actually use the system. This, too, describes a situation in which certain application domains may not be accessible. In short, online services require considerable user sophistication for optimal use. For example, successful uses of e-Bay and other online auction systems to optimise bidding has already generated a whole class of 'sniper' applications which exploit online auction deadlines to generate winning bids in the remaining seconds before the auction expires.[21] Similar bidding management systems are used for public procurement systems, creating a potential barrier to the equity of such systems across spectrum of client skills, which are not necessarily perfectly correlated with the ability to deliver 'value for money' in public procurement.

Finally, progress in developing some application domains may reflect the capabilities of suppliers. For example, in a sample of European companies developing or deploying CRM (customer relations management) systems at the turn of the century, it was found that users were mostly rejecting consultant advice to implement 'comprehensive' CRM systems in favour of systems with more limited functionality – in other words, they were prioritising their service development according to their own capabilities and a perception of which elements of CRM would have the greatest payoff for their business.[22] In the domain of e-government services, the problem of service supplier capabilities is often highlighted and a number of authors have attempted to create models of the development process needed to advance e-government applications (e.g. Layne and Lee, 2001; Lee, 2010; Scherlis and Eisenberg, 2003; Klievink and Janssen, 2009).

4.3. Managerial implications of Barras' reverse product cycle

Confronted with the idea that ICT-based service innovation proceeds from promulgation of a standardised model to a phase of incremental improvement involving learning by doing would suggest that 'putting in place' e-government services and learning from experience in their use was a pre-requisite to reaching the third stage in which Barras suggests users will have a more profound role in service innovation. However, it is unclear what would signal readiness to enter this third phase if the degree of interaction with users is modest or non-existent. In short, one might take the first two phases of the Barras model as the ends of the story (at least for the foreseeable future) and conclude that the highest priority is to learn from the experience of other implementers of e-government systems what is the best way to standardise such provision.

A considerable amount of exchange and sharing has occurred in the last decade that is largely organised around this model of defining a somewhat standardised approach – what should be included in e-government applications, how they should be made more accessible, and the sets of debates around their effectiveness compared to alternative means of service delivery. This process assumes that an appropriate starting place for such development has been identified and that it can be reliably refined through some sort of evaluative process. In some cases, this will be true. E-government services that involve a transactional element can be compared to alternative means of service delivery and their take up and relative efficiency can be assayed. Whether this same process can be followed with regard to other e-government functions such as eliciting citizen involvement and co-operation or even eliciting collective action are more uncertain.

The approach suggested in this paper recognises that there are advantages to informatising services and stimulating co-production, but we are agnostic as to whether these approaches will prove effective for 'customers' or citizen users of such systems and therefore be taken for use by them. The incentives and biases are ones that favour the supplier. When the supplier is a market participant, the issue of take-up is of central importance because it governs whether a particular service is viable. In the case of government services, the imperative to offer such services because doing so is seen, in the first instance, as providing opportunities for government to enter the Information or Knowledge Society may increase the risk of discounting or ignoring the way in which these services are used.[23] This heightens the importance of evaluation because it is only through the evaluation of the use of such services that it might be discovered that the 'general formula' for their provision may be flawed and that some other starting point should be chosen in attempting to build citizen engagement and use of such systems.

Thus, in relation to the managerial issues of e-government service development, the Barras model creates a set of risks. First, the presumption is that the motivation for initial diffusion of e-government services is that there are more efficient means of delivering services online than can be achieved through alternative methods of delivery (Barras first phase). As we have suggested, success in fulfilling this motivation is by no means certain. At this phase, at least, there are some clear indicators

[20] The process of informatisation has been studied by numerous authors. (Zuscovitch, 1983, #1334) had, for example, conceived of the trade-off discussed here between efficiency and variety in the context of the then primitive information technology.

[21] See http://www.techradar.com/news/internet/the-best-free-and-paid-ebay-sniper-software-667696 (Last Accessed 18 March 2012) for a review of such software and a discussion of its application.

[22] See Steinmueller (2003).

[23] It can be argued, for example, that the problem is one of user capabilities rather than the qualities of the services on offer that are affecting the take up and use of such services.

about whether success has been achieved if the use of e-government services is voluntary whilst it is less true if these services become obligatory. That is, that the use of these services becomes an obligation for discharging statutory obligations such as paying taxes. Of course, there are other obligatory elements of citizen interactions with government for which issues of choice are less relevant, statutory regulatory stipulations and compliance are more difficult to make consistent with co-production, although some of the intermediate stages such as submission of auditable information in support of regulatory compliance is an example. In these cases, the method of service delivery may actually impose costs and risks on citizens without corresponding advantage, a feature that may account for some resistance to the use of these facilities.

Second, whilst private suppliers are ready and able to capture information about their users in order to learn by their behaviour, the willingness and ability to do this in the public sector is far more constrained because of concerns about privacy and surveillance. Whether the public sector can learn in the second phase of Barras' reverse product cycle is therefore less clear. Third, with respect to the third phase of Barras cycle there seems little evidence that governments are moving towards greater user involvement from which more radical service innovation opportunities might emerge. This concern is highlighted in our empirical examination of two e-government services in the UK in Section 6. What we are suggesting, therefore, is that the Barras model of e-service innovation may encounter a number of specific problems in the case of the public sector that suggest its modification and the construction of alternative means of evaluation and feedback to compensate for the lack of the market feedback provided by e-service delivery in other contexts.

5. Productivity implications of the time-based model

The productivity implications of the argument put forward above are not straightforward, as conceptualisation, measurement and empirical analysis of productivity in services are not straightforward per se (see Griliches, 1992; for a recent review, see Djellal and Gallouj, 2008; Grassano and Savona, 2012). As argued throughout this paper, the same flaws that affect the conceptualisation of innovation in services are reflected in the measurement of productivity.

National income and product accounts employ a mixture of methods for measuring service output that differ by sector. These methods are variously based on different approaches: (1) inputs are taken to be outputs, (2) expenditure is deflated by an index not specific to the sector of service output, (3) physical measures of services delivered (e.g. letters delivered), and (4) expenditures divided by a sector specific price index derived from expenditure surveys (as in the case of hair dressing) or from cost estimates (Oulton, 1999). Each of these measures is an approximation which aims at treating service output in a comparable way to what is done with industries either with relative homogeneous outputs, e.g. copper wire or with heterogeneous outputs, e.g. furniture. As argued earlier, a significant problem arises in the presence of technical change which may simultaneously make outputs more heterogeneous and lower the costs of their production. This can happen in furniture as well as services, but it may be more profound in the case of services due to the nature of information and communication technologies.

Turning more specifically to e-government service production, the measurement of productivity is affected by a further series of conceptual and measurement problems and the attempt to resolve some of the issues mentioned above are possibly even less satisfactory. For instance, a recent contribution (Diewert, 2011) proposes methods of productivity measurement that assume prior information on the quantity of non-market output – for which price evaluation are either purchaser or cost-based. If no information is available on the quantity of output then – rather simplistically – output growth is set equal to input growth (Diewert, 2011). This subterfuge was pointed out as a major drawback in services output (and productivity) measurement by Griliches twenty years ago (Griliches, 1992).

Employing the framework we have defined may be helpful in the conceptualisation of service sector production and innovation issues. But is it helpful in examining their productivity?

Extending the argument of Grassano and Savona (2012), which argues for reworking the definition of service output in line with the Lancasterian framework adopted here, we suggest a similar effort is needed on the input side. Productivity increases might well come from input-saving innovation – mostly associated to process innovation. In the case of services, as well as in goods, input-saving productivity increases are to be considered in terms of substitution between different intermediate inputs, including energy and time along with labour and capital. This would allow us to "weight" from a welfare perspective the type of input-saving productivity enhancements and rank the specific input-saving process in terms of social desirability. For instance, energy saving (process) innovations might well be more desirable than labour-saving (process) innovation from a welfare perspective. Correspondingly, deskilling innovation may be less favourable than up-skilling innovation if we are able to choose between two different (and seemingly equivalent) labour-saving productivity increases. Along the same lines, time-saving productivity enhancements have to be considered within an innovation framework and assessed against capital-deepening or capital-widening related productivity increases.

Our model focusses on the productivity increases obtained from innovation offering time-saving opportunities, innovations that allow changing the intensity of informatisation or degrees of co-production. Accounting for the interaction between co-production and information allows us to assess productivity increases on both producer and consumer side.

On the consumer side, the model adjusts for the entire spectrum of choices of time allocation between self-production and different degrees of co-production – up to the total outsource to the service provider of service provision. This applies to any service, including those with specific obligatory public requirements.

On the producer side, productivity increases can be achieved through several channels; all those considered

here involve the interaction between time-saving and the extent of co-production. First, the service provider might aim at enlarging the extent of co-production, assuming that this will reduce labour costs and, under certain conditions, increase the demand. Second, the informational component of the service, which is a typical sunk cost, is going to be spread over a larger consumer base, where this latter is achieved either by increasing the extent of co-production or by directly increasing the demand.[24] Third, the informational component of the service – in line with the traditional Barras' argument – can benefit by increases in standardisation, which in turn might increase market shares and productivity. Finally, the degree of co-production might be extended to a pure self-service case, in line with what predicted by Gershuny (1978).[25] The dramatic gains in productivity as a result of self-service might also be assessed against what has been labelled a 'transaction-multiplier effect' (Mesenbourg, 2000), and, despite the original application of this term to e-business services, it might well be occurring in e-services in general.

6. Grounding theory in experience: e-government services in practice

This section illustrates two empirical applications of the conceptual framework developed above. The aim is to ground theory in practice and exemplify some of the evolutionary features of service innovation, in terms of the time-based model proposed. A central focus of this section is to illustrate the tendency of e-government services to get 'stuck' in the first phase of Barras' service product life cycle where expansive general purposes are defined and the difficulty of moving out of this stage when user information is not systematically retained and co-production activities are minimal or non-existent. Because of the uncertainties about user take up, the 'designers' of online service offerings play a pivotal role in this evolutionary or search process for defining the nature and characteristics of services. In the case of e-government, it is worth noting that decisions about website development are not taken independently of the history and political features of government communication more generally, though we choose not to enter this debate here.

We offer a pilot study of e-government implementation in the UK involving the NHS Direct and DirectGov sites. Both sites are highly regarded examples of e-government services.[26]

NHS Direct is a website that operates with the slogan 'clinically checked, expert health advice online and by phone, at a time convenient to you.'[27] In practice, NHS Direct is organised in order to provide this 'advice' in several different ways. From the outset, it is a site that elicits co-production of this advice from users by providing a menu of possible symptoms. Understandably, there is a clear interest in the design of this system to providing a 'triage' of possible grave consequences of symptoms.[28] However, a further aim of the site is to shift the allocation of time between those NHS services based on direct interpersonal contact (visits to surgeries or to the Accident and Emergency (A&E) departments of hospitals) and the patient. In doing this, it is necessary to invest in both informational resources (the NHS Direct site) and complementary services (online and phone services with clinicians prepared to respond to patient queries).

The site contains a considerable amount of information about health-related issues. However, it strongly organised around the co-production of diagnoses using one of two primary tools – a 'symptom checker' or a 'patient decision aid.' The latter involves nine areas ranging from amniocentesis to osteoarthritis of the hip where patients typically face important decisions involving weighing risks of alternative treatment options. The site includes an option to 'join' the NHS Direct community and a connection to social network sites (Facebook and Twitter), which will be discussed further below.

DirectGov is a very large and multi-purpose site. Because of its size, it is difficult to concisely describe or characterise. Compared with NHS Direct, there is less direction given to the user and dramatically less opportunity for co-production (other than the co-production involved in navigating the site). The home page of the site identifies sixteen (16) possible section branch points as well as several current news boxes, an opportunity to focus on local services (with ten (10) possible service needs identified and customised to the user's postcode), a listing of the ten (10) most popular service subjects, and, given this complexity, the further choice to examine the 'beta' version of a new Website which seeks to simplify the current site.[29] Choosing one of these options leads to further

[24] In the case of public services, this is likely to be facilitated by regulation changes, which make the 'consumption' of a particular service compulsory.

[25] Gershuny (1978) predicted the end of the service economies due to increasing technical change, which would have led societies and economies to self-produce most of the (final) services needed in households. Empirical trends have not ended up supporting this, though the idea of self-production as the highest level of co-production is reprised here.

[26] For example NHS Direct was awarded an excellence award by eHealth Insider, a trade journal in the field of e-medicine: see http://www.ehealthawards.com/excellence-in-major-healthcare-it-development (Last Accessed 1 April 2012). One of the system developers for DirectGov 'System Associates' was the runner up several years ago for the British Computer Society's award for information management; see http://www.systemassociates.co.uk/about-us/awards.aspx (Last Accessed 1 April 2012).

[27] http://www.nhsdirect.nhs.uk/ (Last Accessed 1 April 2012).

[28] For example, pursuing advice about the treatment of a skin rash involves a considerable number of questions that relate to the possible diagnosis of meningitis, an acute and possibly fatal inflammation of the protective membranes of the brain and spinal cord whose prompt treatment can make a major difference in health care outcomes.

[29] Of interest, the beta version of the new and improved DirectGov site appears to rely very heavily on search engines for navigation. This dramatically reduces the clutter, but presumes that the user will have a pre-existing vocabulary of search terms. This can be seen as a substitution between co-production and user capability investment, a trade-off with rather uncertain results. Although it is true that Google-style search engines have prevailed over Directory-type listings (similar to earlier versions of Yahoo and still maintained by the Open Directory Project), there is some evidence that typical use of search engines pursues the 'line of least cognitive resistance,' perhaps not an appropriate approach to understanding the way that government's choose to structure information resources,

choices. For example the 'crime and justice' selection (one of the 16 branch points on the home page) leads to a page with fifty four (54) possible branch points, ranging from 'Your rights at a police station after being arrested' to 'Find local crime information.' Following the latter of these links leads to a page where the user is able to enter their postcode to find the incidence of various crimes in their vicinity. This is very detailed information: separate monthly counts of eleven (11) different crimes ranging from 'violent crime' to 'shoplifting' are provided for over a year with an 'anonymised' location of these crimes to over 760 thousand distinct locations in the UK which are, in turn, mapped into 1.76 million active postcodes for the purpose of user query and information display.[30] In the case of DirectGov the time saving sought by government includes direct citizen contact at local council and other offices for the purposes of providing information or guidance. In addition, of course, citizens may also achieve time-savings by avoiding such visits or becoming more informed so that their visits are more productive (including more productive for government service delivery).

Both sites have strong elements of customised development although each could be seen as a template for the design of similar services. NHS Direct in particular has pioneered 'computer assisted decision support systems' (a kind of expert systems designed to help call centre and nursing staff to respond to queries – this is literally an online medical consulting service and therefore very much engaged with people). On the other hand, DirectGov is a veritable civics encyclopaedia with an enormous amount of 'static' or reference information (e.g. descriptions of the award system in the UK) as well as current information generated from large datasets such as the crime statistics for every postcode in the country.

Basically, neither NHS Direct nor DirectGov offers the capacity for users to interact in a visible way on their sites. The implications of user interaction defined as involving an element of 'joint control' of information is somewhat controversial for either site, but particularly for NHS Direct whose definition of identity begins with the phrase 'clinically checked,' which is not a formula for co-production of information content (although it is not inconsistent with co-production of service). However, both sites also offer connections on a social media sites and here is where clear distinctions can be seen to be operating. The NHS Direct site has authored submissions inviting interaction and the comments generally reflect civil and measured social norms in public communication. By contrast, at the DirectGov site, no comments are made by 'officials' and social norms have not been established, many comments are full of rude and inappropriate postings.

Does either of these sites offer a reason to engage in 'persistence,' a feature that is sometimes associated with the building of virtual communities?[31] The answer is, not really. Neither site offers a meaningful 'membership' option. Although the NHS Direct site offers the ability to become a 'member of the NHS Direct Community' the sign up for membership is basically a collection of contact details and the user is not provided with the usual tools for self-identification (password protected login) and is not told what will happen next after agreeing to become a member.[32] DirectGov does not offer any facility for 'joining' with the site. As a consequence neither site offers the possibility of retaining user-specific information, an essential feature for supporting the re-use of user-entered (co-produced) information or for customising access to the site according to user interests (taking further advantage of informatisation). Transactions with either site are therefore based on ephemeral one-off interactions by which a user navigates to a particular point in the site, which may or may not deliver the information that they are interested in and no record is retained of their interaction. Thus, co-production activity is also ephemeral and has to be reproduced in every 'session' that the user may initiate. This is clearly antithetical to the realisation of productivity gains by either the service provider or the user from co-production. Similarly, gains that might be possible in informatisation are frustrated by the absence of information retention.

It is important to note, however, that the productivity implications of these sites in the use of government services may be very significant. Taking NHS Direct as an example, the organisation' chief executive estimates that in 2010/11 'the core service saved 1.6 million unnecessary GP surgery appointments, 1.1 million A&E attendances/999 calls, and 0.5 million other face-to-face appointments.[33] The delivery of the core services that are largely responsible for these savings cost £118 million pounds, suggesting that if the average cost averted of face to face or emergency (999) calls was greater than £37, the service was producing a net cost savings to taxpayers.[34]

Both NHS Direct and DirectGov bear evidence of very substantial customised design. In other words, they cannot be taken to exemplify the 'radical' starting point of imitating a general set of e-government functions. Instead, each begins with a very complex and innovative 'radical' innovation starting point based on customised design. In the case of NHS Direct, this involves both the systematised enquiry system and the design of this system to reflect clinical best practice in triaging patients with life threatening conditions (a substantial improvement on many other online e-medicine sites). In the case of DirectGov, the aim of providing links to a vast array of government services in a single 'umbrella' site is also highly innovative.

see Griffiths and Brophy (2005) for a cogent review of literature on searching behaviours.

[30] The latter figure from http://en.wikipedia.org/wiki/Postcodes_in_the_United_Kingdom (Last Accessed 2 April 2012).

[31] Mateos-Garcia and Steinmueller (2003).

[32] What in fact occurs is that the 'member' is periodically sent e-mail messages inviting them to meetings where they might provide unspecified 'feedback' about NHS services.

[33] www.nhsdirect.nhs.uk/About/CorporateInformation/OperatingStatistics/AnnualReport2010-2011 (Last Accessed 3 April 2012).

[34] The cost figure is from the Annual Report, p. 54 at http://www.nhsdirect.nhs.uk/About/CorporateInformation/OperatingStatistics/~/media/Downloads/NHSDAnnualReportAccounts2010-11.ashx (Last Accessed 3 April 2012).

In terms of the Lancasterian framework, both the NHS Direct and DirectGov sites suggest the challenge of creating a more generalised 'template' or model for e-government service provision. Each site is highly complex collection of services with varying degrees of information content and co-production opportunities. Developing an appropriate 'characteristics' space to more broadly characterise these services and to provide a systematic way to relate co-production and informatisation opportunities is an interesting and difficult task for further research.

7. Conclusion

This paper extends recent efforts to utilise Lancasterian approaches to product definition in service contexts and thereby to better define service output. The specific focus of the paper on a central feature of contemporary society, the use of ICTs, is shown to allow for innovations that re-allocate the productive and co-productive efforts of consumers and producers to different degrees depending on the design of co-productive opportunities and the nature and degree of informatisation investment. In this framework productivity increases can be seen as involving time-saving changes in the production and consumption of services.

From the viewpoint of the producer, service 'offerings' (which involve varying degrees of innovation – radical or incremental change) imply trade-offs between variety and efficiency. Greater efficiency from the producer's viewpoint may be obtained by taking choices to stimulate co-production. However, to achieve higher levels of co-production, it may be necessary to make choices involving substantial investments in informatisation. The mediating variable influencing the choices of both clients and producers is the effect of these choices on time allocation. Hence, the productivity improvement implications of changes in service definition and delivery are best understood to involve both producer and consumer time-saving, with producer time-saving more readily translatable into pecuniary cost savings. The take up of innovations in service definition and delivery depend on consumer preferences, time constraint and capabilities. The heterogeneity of these elements across clients represents a fundamental uncertainty for the reaping of the benefits from innovation.

The framework proposed here is assessed against the reverse product cycle model offered by Barras which, though developed in the early 1990s prior to widespread access to the Internet, remains influential in guiding service innovation strategy. Despite reprising some of Barras' features, particularly linked to the use of ICT to develop incremental and radical innovation in services, there are fundamental differences in the way the two models embody the role of consumers and the importance of time-saving innovations. Implications of these differences emerge when considering the case of e-services and particularly that of public e-services.

E-services generally may be considered as having detailed configurations of characteristics in which the most important from the viewpoint of producer productivity are those that involve the development of co-production opportunities and informational and computational features that benefit from the economics of information. Within this framework, we considered the fundamental uncertainties facing service providers as they develop and offer services for which demand is highly uncertain because of the evolution of user capabilities, the complex allocation issues surrounding user time allocation, and the uncertainties of project development.

On the one hand, producers can ignore the possibilities for informatisation and co-production in which case they are likely to face constant returns to scale in the production and delivery of services. On the other hand, suppliers may allocate capital and labour to the design and delivery of services that benefit from informatisation (which brings economies of scale through the expansibility of information and the spread of fixed costs of information processing applications) or to the design of services that facilitate or enable co-production (which may reduce the costs expended in service delivery whilst compensating users indirectly by offering higher quality or more directly by sharing costs savings and reducing service prices). We have emphasised that proceeding along either of these cost saving (and productivity improving) lines of service design development is uncertain. Merely saying that advantages can be achieved in these ways does not guarantee that they *can or will* be achieved since such achievement will depend both on user preferences and capabilities, which are largely hidden from the supplier. Nonetheless, either of these directions does offer clear productivity improvement advantages and therefore are, at minimum, worth careful consideration in further research.

The advantages of informatisation, in particular, provide an incentive to adopt standardised solutions, a tendency that is suggested by Barras' reverse product cycle model. In applying this model to e-government services we note that advances are often initiated by adopting a standardised or 'best practice' approach but that this type of approach may create risks of becoming 'stuck' in the second phase of Barras' typology of development in which incremental improvements are sought on the 'radical' (in the context of e-government services, radical often means implementing of a particular e-government solution relative to existing practice). These incremental improvements may become a barrier to further advance because such advances involve (a) complexity, (b) specificity, and (c) interactivity and (d) the evolution of user capabilities.

We then briefly examined two leading UK e-government sites to see whether the theoretical framework involving service design allowing for co-production might offer a useful interpretive framework – NHS Direct and DirectGov. Both sites offered few opportunities for co-production although NHS Direct is oriented to high levels of user interaction in providing diagnostic information both online and as a 'feeder' to call line services when symptoms suggest more immediate medical attention is required (linked services). Neither site offers the sort of membership option that would sustain participation or allow users more extensive opportunities for co-producing information and neither site offers user co-production of content on the main site.

Finally, we suggest that there is a need for more comparative research about the portfolio of Lancasterian attributes of e-government sites in order (a) to better define (i.e. to define from actual experience) the nature of e-government, (b) in order to suggest opportunities for further advance in e-government services.

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