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# Models as Measuring Instruments

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# Models as Measuring Instruments:
# Measurement of duration dependence of unemployment

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*Abstract:*
Nancy Cartwright views models as blueprints for nomological machines - machines which, if properly shielded, generate lawlike behaviour or regularities. Marcel Boumans has argued that we can look for devices inside models which enable us to measure aspects of these regularities. So, if models do produce regular behaviour (Cartwright), they might perhaps generate numbers about phenomena in the world, provided we can locate a good measuring device in the model (Boumans). How do they do this? Models are often understood to consist of internal principles and bridge principles. Both of these play a role in the measuring process. This paper suggests that we can understand the internal principles to be responsible for generating the regularities displayed by the model - and for many users of the model, this is sufficient use. The bridge principles (following Cartwright – "the real bridge principles") are a matter of picking the right mathematical representation to make the model work with respect to some real world case at hand. These "real" bridge principles may enable the model to generate numbers and so serve to make the model into a measuring device.

This paper explores this construction of a measuring device of duration dependence of unemployment. Since search theory can't be made operational for this purpose duration models which model of the outflow process of unemployment with a Weibull function are taken as a representation of reservation wage setting in search models. As I show, this Weibull function serves as a bridge principle to make a measure of the elasticity of response between unemployment benefit and duration of unemployment. It enables measurement to take place by modelling behaviour according to some assumptions, which operate as constraints. While this Weibull function serves this purpose, its assumptions are arbitrary rather than connected to theory, and measurements generated with this bridge principle turn out to be highly sensitive to its specification. The Weibull function does enable the model to function as a measuring device, but the lack of ability to make newly invoked unobservable variables operational makes it of dubious worth.

*Keywords*: Economic Models, Measurement, Transition Data, Search theory, Duration Dependence of Unemployment, Theory of Unemployment

*JEL-classification:* B, J

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## 1 Introduction

In economics models serve many purposes. Models are used to make predictions about possible outcomes and so to evaluate economic policies. Models are used to give detailed descriptions of the economy. Or models are used for their explorative nature and hence serve as tools in theory construction.[1] An overlooked function of models is that of a measurement device. In many cases models generate numbers when confronted with real world data. And although economists rather speak of 'assessing' or 'estimating' - and in this way make preservations as to the accuracy of the measures - we can think of this generation of numbers as measurement since it suggest that there is a correspondence between the realm of numbers and phenomena in the real world. Marcel Boumans (1999a) shows that models contain devices, which enable to function as measuring instruments since they are representations of stable relationships.

The aim of this paper is to provide an analysis of how economic models may function as a measuring device. This is done by a case study of Tony Lancaster's duration model of unemployment published in Econometrica as *Econometric Methods for the Duration of Unemployment* (1979). In this article Lancaster suggests a statistical method for using duration data of unemployment, which is now widely used in studies on (long term) unemployment. Many others followed this method specifically for the measurement of duration dependency. In his article Lancaster also estimates duration dependency of unemployment for a sample of British unskilled, unemployed workers. The topic of measurement of duration dependency is therefore chosen for this paper.

This paper proceeds as follows. Section 2 will clarify the account of models as measurement instruments. In section 3 the phenomenon of duration dependence and its causes is discussed, whereas section 4 presents the framework for the analysis of duration dependence. The case study at hand, the model of Lancaster, is discussed in section 5. Sections 6 analyses respectively the internal principles and the bridge principles of the model, and the way the model is calibrated. Finally, conclusions are drawn in section 7.

## 2 Models as measurement instruments?

The use of models as a measuring device may not seem straightforward. What is it that makes models suitable as a measurement device? In methodological literature several accounts of models are known.[2] Rather than to focus on the differences between these accounts I will stress the

[1] A more detailed description of the functions models serve can be found in Morgan (1999)

[2] Several, partly overlapping accounts of models can be found in methodological literature, like the semantic account, the syntactic account, Mary Hesse's analogy account and Nancy Cartwright's simulacrum account. Daniel Hausman, Ronald

similarities here. Most accounts of models seem to have two elements in common. First of all, *models are simplifications*. In order to describe the real world irrelevant elements are left out, in such a way that the model represents only what we think is the essence of the phenomenon. From large econometric macro models to game theoretic models, they all have in common that they leave out irrelevant aspects of the phenomenon and in this process idealisations are usually unavoidable. The extent to which idealisations take place however, is a matter of degree. For some models are aimed to give detailed descriptions of the world whereas other models are such an idealisation that we can think of them as caricatures: they represent some essential feature of the world only in a distorted way (Gibbard and Varian, 1978). Secondly, *models display structure*. In economic models this structure consists of assumptions and relations between variables prescribed by and consistent with a particular theory, and in most cases this structure is represented mathematically. Structure, however, is not enough. Structure forms an uninterpreted system and models need interpretation. As Gibbard and Varian (1978:666) put it: "In economists' use of models, there is always an element of interpretation: the model always tells a story".[3] Therefore they claim that a model is "a story with a specified structure" (ibidem).

This account is not contested in methodological literature. However, I would like to add to this account. Models are set up carefully to let them produce a particular behaviour of endogenous variables and in order to do so safeguards are needed. Disturbing factors to the model are shielded off by ceteris paribus conditions and restrictions are placed on parameter values in order not to let variables reach extreme values so that the model will not explode. So, if the conditions under which the model operates are regular, the model will operate regularly and hence will be generating regularities. Models therefore don't tell just a story, they tell the *same* story. And they will do so over and over again since they are designed to do so. Therefore, models are stories with specified structures that produce, when submitted to the same initial conditions, regular behaviour until an end condition is reached. And it is exactly this regularity in behaviour that makes it possible to use models as measurement instruments.

Many of these aspects can be found in the work of Nancy Cartwright and Marcel Boumans. According to Cartwright (1999) models are blueprints of nomological machines; machines that produces lawlike behaviour. A nomological machine is "a fixed (enough) arrangement of components, or factors, with stable (enough) capacities that in the right sort of stable (enough) environment will, with repeated operation, give rise to the kind of regular behaviour that we

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Giere and Margaret Morrison and Mary Morgan provide other accounts. For an overview of these accounts see for example Morgan (1998).

[3] A point also stressed by Mary Morgan (2001)

represent in our scientific laws" (Cartwright, 1999: 50). Parts of the machine have the virtue – or in her terminology the capacity – to make the machine function as it does. The lawlike behaviour of nomological machines however is only apparent in situations where confounding influences are properly shielded off and in the real world economy this is almost never the case, as one cannot control all disturbing factors. The assumptions of ceteris paribus are therefore rarely met in the world. As a consequence, models, which function with real data in their initial conditions, do behave regularly but are subject to disturbing influences.

For measurement however, regular behaviour of a model alone is not enough. For measurement models need empirical input. Therefore models must somehow be connected with the actual world. In Nancy Cartwright's account this connection works through the Logical Positivists' account of internal and bridge principles.[4] Internal principles "present the content of the theory, the laws that tell how the entities and process of the theory behave" (Cartwright, 1983:132). They bear on the relation between the world and the model and have the character of universal laws. Predictions of what would happen in particular situations follow from the internal principles. My own view would be to think of the internal principle of a model as a *mechanism*, where mechanism can be interpreted in the Machamer-sense: "Entities and activities organized in such a way that they are productive of regular changes from start or set-up to finish or termination conditions" (Machamer, 2000: 3).

In many cases it suffice for economists to investigate the internal principles only. Let's take for example Albrecht and Axell's equilibrium search model (1984), as a typical exemplar of a particular approach to model building. In their analysis they present a model using search theory for the analysis of wage setting and the effect of unemployment benefits on unemployment. After their model is specified mathematically they run a test of the model with fictitious numbers. For important but unknown variables fictitious values are 'plugged in' and a comparative static analysis is performed. Since there is no real world input in the model, no actual phenomenon is measured. The test is performed in order to see whether the model generates the right kind of behaviour and their concern is in the first place about the internal principles of the model.

However, for measurement are, besides internal principle, bridge principles needed. Bridge principles "are supposed to tie the theory to aspects of reality more accessible to us" (Cartwright, 1983:132). In the Logical Positivist' account they bear on the relation between the model and mathematics and have contrary to internal principles no universal character. They only hold when the circumstances are ideal. That is, they hold ceteris paribus. The bridge principles are supposed to

[4] See for example Carl Hempel, 1966: 72-75

tie theoretical terms to direct observations and the mathematical equations used therefore present the model in an operational form with accessible, that is, observable variables. In this way they function as the correspondence rules Logical Positivists require scientific theories to have. It follows that phenomena in the world are tied to empirical data by the twofold set of internal and bridge principles which both are integrated in models. The internal principles provide autonomy by means of the generated regular behaviour whereas the bridge principles assure the connection with the real world.

The twofold set of internal principles alone doesn't make models measuring instruments. The internal principles of a model may appear to be robust generalization, but they may be inexact and inaccurate due to disturbing factors. Boumans (2005) however argues that the inexact and inaccurate relations can be transformed into exact and accurate relationships by *calibration* and in doing so make the model suitable as a measuring device. In this way the problem of lack of control over disturbing factors can be circumvented. In the literature different interpretations of calibration can be found.[5] In this chapter calibration is taken as 'fine tuning' of parameter values. Thus, provided that models are adequate under different circumstances "A measurement model (…) produces exact and precise regularities" (Boumans, 1999a: 398). It is the triplet, internal principles, bridge principles and calibration, which make models suitable as *number generating machines*, hence measuring instruments.

In the next sections this idea of models as measuring instrument will be explored for measurement of duration dependency of unemployment in search models and a particular model will be investigated by using this framework of internal principles, bridge principles and calibration.

## 3 The phenomenon of duration dependence and its causes

After decades of prosperous growth Western economies faced in the 1970s an economic slowdown and a consequent rise in unemployment. This rise in unemployment went hand in hand with a fairly new phenomenon, particularly in Europe, that of long term unemployment (LTU). Even when the economy recovered a portion of unemployed were not able to find new employment and remained unemployed for a long period of time.[6] Hence unemployment is disproportionally concentrated on a few individuals who suffer long spells of unemployment. This phenomenon gave a strong impetus to new theories in order to explain the phenomenon of LTU. One line of reasoning is the hypothesis of *duration dependence*. Negative duration dependence is assumed to exist when the probability of leaving unemployment depends on duration. That is, when agents' chances of leaving

[5] One interpretation of calibration is that as method of estimation or "tuning". Another interpretation is that as "testing" of a model. See also Boumans (2001), and Hansen and Heckman (1996).
[6] Mostly taken as longer than 6 or 12 months

unemployment decrease because of the very fact that he or she is unemployed already for a long time. The causes that bring this effect about are multiple. Long term unemployed might lose professional or social skills, become discouraged, adjust to lower standards of living or may be stigmatised and become subject to discrimination of employers. As a consequence, of equally skilled or experienced unemployed the worker with the shorter unemployment duration will leave unemployment more quickly. As Machin and Manning put it: "It seems very likely that both high unemployment and a high incidence of LTU have a common cause, an "X" factor or factors which has resulted in a collapse of exit rates for the unemployed at all durations. The usual suspects for the "X" factor are generous welfare benefits, powerful trade unions, high minimum wage, employment protection, skill-biased technical change etc." (1999: 3106-3107). Duration dependence is thus a total outcome effect of a set of multiple, singular causes. In general however it is believed that the total outcome effect is negative and that unemployed who are out of work for a long period of time become even more detached from the labour market. Therefore, it has been argued that high long term unemployment is a cause of high unemployment itself (Machin and Manning, 1999: 3087).

An important source of duration dependence that is studied very often is a time varying unemployment benefit structure. In many countries unemployment benefits change with the duration of unemployment or might end all together after some point. Research indicates that prior to depletion of unemployment benefits (at time T in figure 1, when the unemployment benefit level drops from B1 to B2) an increased flow out of unemployment is observed. Researchers infer from this that there is a corresponding drop in reservation wage (the wage level for which unemployed are indifferent between accepting a job and staying unemployed) during the two or three weeks preceding time T (Layard, Nickel and Jackman, 1991: 251). The reservation wage therefore is assumed to follow the path presented in figure 1. The fall in reservation wage however is a case of positive duration dependence: the approaching depletion of unemployment benefits is assumed to

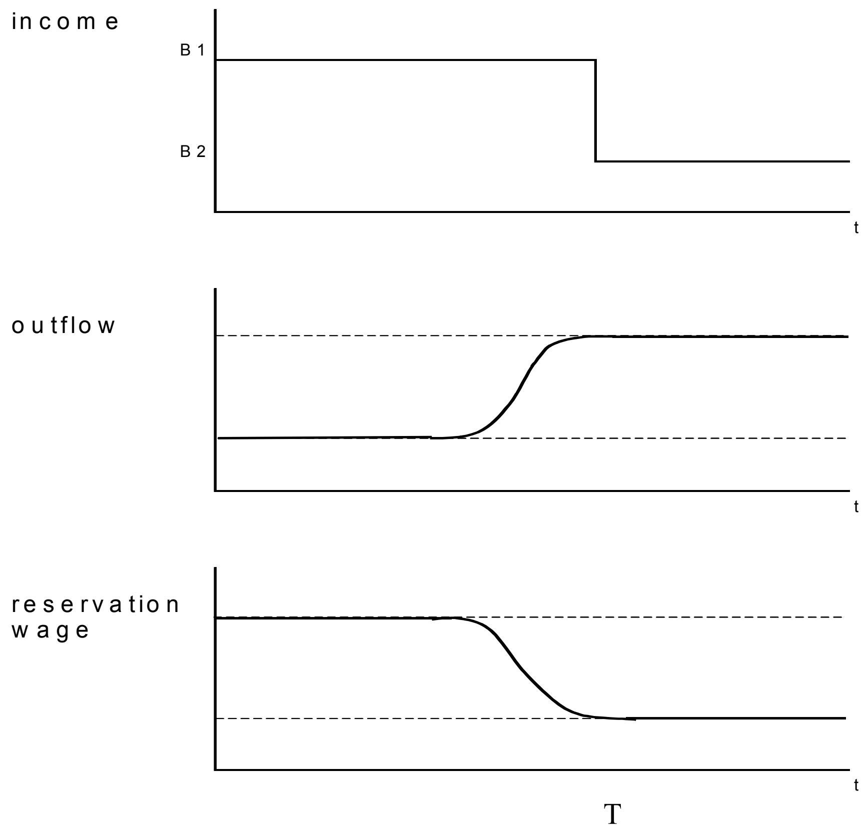


Figure 1: Income, outflow and reservation wage in a time varying unemployment structure

make the unemployed less 'job choosy' which increases their chances of leaving unemployment. As a consequence, the reservation wage is thought to decrease with duration and is hence a time varying variable (Layard, Nickel and Jackman, 1991: 251). Economists tried to measure this duration dependence - that is the elasticity of a causal factor on unemployment duration - by using empirical data of unemployment duration.

## 4 The framework for measurement of duration dependency

Up till the 1960s the problem of unemployment was primarily analysed in terms of stocks of unemployed. The establishment of the idea of a natural rate of unemployment by Friedman (1968) and Phelps (1969) redirected the attention of economists from macroeconomic approaches of unemployment, as used in the Phillips curve analysis, to investigations of the causes of unemployment on a microeconomic level. This originated a new approach in labour economics, which was based on search theory and analysed unemployment in terms of flows rather than stocks. Peter Diamond (1998: 273) defines search theory as "the analysis of resource allocation with specified, imperfect technologies for informing agents of their trading opportunities and for bringing together potential traders". In search theory rational decision making of (unemployed) agents is analysed which optimise their expected flow utility[7] when faced with a known distribution of wages.[8] That means that economic agents are supposed to make a choice between accepting an offered job with a given wage and further search for a better paid job which occurs with a known wage distribution. Unemployment is in this way considered as a productive investment since a higher wage level will eventually offset the costs of an extended unemployment spell. In these models the optimal policy of unemployed is based on the selection of a reservation wage that defines the set of acceptable wage offers given the distribution of wage offers. The reservation wage must be set high enough to make the job acceptable for the unemployed and low enough for the employer to offer the job. This general idea of search theory resulted in a variety of models, like search models, matching models and efficiency wage models.

A variety of ideas are used in search models of unemployment. Early search models assume the existence of wage setting by firms with a certain known distribution. When a job arrives, identical workers decide to take it or to reject the wage offer. Unemployment is in these models thus caused by the rejection of wage offers by workers. Later models include all kind of heterogeneities in the labour market, like heterogeneity in information, skills of workers, reservation wage, location etc. These make it necessary for both firms and workers to spend resources to find productive job matches and hence cause mismatch. What search models have in common is that they use the steady state condition for the economy, that the flow into employment is matched by an equal, break-up of existing jobs and hence inflow equals outflow.

However, when we confront theoretical search models using this framework with empirical data we find that this theoretical framework is not well suited for actual measurement of effects of duration dependence. Important variables like the reservation wage are not directly observable, or are even impossible to derive from duration data.[9] Moreover, in the case of duration dependence the reservation wage is not constant but a time varying function of the unemployment duration, making observation even more complicated. Data we can 'observe' from unemployed involve accessible characteristics like age, work experience, education and unemployment duration. Historians and philosophers of science like Brian Ellis (1966) and Michael Heidelberger (1994a, b) show that one way to deal with such a problem is trying to find another variable to which the phenomenon is functionally correlated with. So, if we want to have search models to generate real world numbers,

[7] The summed and discounted value of expected future income.
[8] Or prices. Search theory has its counterpart in the analysis of consumer behaviour in the goods market
[9] Since Flinn and Heckman (1983) labour economists also try to infer the reservation wage from wage data where the lowest accepted wage is taken as the reservation wage. Also do contemporary researchers make use of surveys in order to study the reservation wage. Both methods however are very sensitive to the exact specification.

we perhaps could resort to an operational model in which the unobservable is replaced by a covariating variable, which we can confront with observable data. Lancaster (1979) provides such an econometric method that is consistent with standard search theory. It is based on an econometric specification of the outflow rate out of unemployment in terms of conditional probabilities of an unemployed leaving unemployment and it makes use of three related probability distributions. The main framework of this approach is that of the *hazard function* (or *instantaneous failure rate*).[10] The hazard function is used for the analysis of objects or agents that move from one state to another after some time. Light bulbs for example move from the state 'working well' to the state 'broke down' after some time. The process of entering or leaving unemployment can similarly be considered as the transition of one (employment) state to another.[11] The hazard rate or the probability of leaving unemployment ($\theta$) is in this approach, in line with search theory, considered as the product of the probability of finding a job (or 'arrival rate' of jobs) $\lambda$ and the probability of accepting the job. The job will be accepted when it pays more or equal to the workers reservation wage *z*. This latter probability $p(z)$ is therefore a function of the distribution of wages. The arrival rate is considered as a function of the labour market tightness; that is, the unemployment-vacancy ratio (U/V). The outflow probability is thus written as:

$$\theta_i = \lambda_i\left(U/V\right)p(z_i) \qquad (1)$$

The hazard rate can be made observable from duration data of unemployment, which are relatively easy to obtain from, for example, surveys at labour exchanges, and may concern completed or uncompleted spells of unemployment. From a duration data set three probability distribution functions can be derived.

The first one, the probability distribution function (in short: *pdf*) *f*(t) can be established from data of unemployment spells. The function determines the percentage failed in time X to X + an (infinity small) interval $\Delta$t. So, it gives the proportion of *all* unemployed who find a job within $\Delta$t of a duration of say, 18 months. This probability is referred to as the unconditional probability of leaving unemployment as it is unconditional on the state unemployed are in. It is uninformative about which unemployed has left the pool of unemployed. This probability is therefore not very illuminative in the analysis of duration data.

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[10] In full: reemployment probability function hazard of failure rate (Lancaster 1979: 940). Other names under which the function appears in scientific literature are, among others, age specific death rate, force of mortality, failure rate, hazard etc.

[11] Unfortunately, since this kind of duration analysis originates from mechanical engineering, which studied the breakdown or failure of physical objects in time, it follows that the (joyful) event of finding a job is interpreted as a "failure".

More informative is the second distribution function, the cumulative distribution function (*cdf*), or more accurately, the function 1-*cdf*. The cumulative distribution function *F*(t) determines the total percentage 'failed' by time X. Consequently the function 1-*cdf* (or 1-*F*(t)) determines the total percentage of a cohort remaining after time X. For this reason this function is referred to as the *survivor function*, and it can be obtained from the *pdf* by integration. The relation between *pdf* and *cdf* is:

$$f(t) = dF(t)/dt \qquad (2)$$

The third relevant distribution function is the hazard rate. The hazard function $\theta$ is the function that represents the *conditional* probability of moving from one state to another. It gives the probability that a say 18 months unemployed worker will find a job. The hazard function thus gives probabilities for unemployed during the different stages of their unemployment spell and is therefore a more useful concept for the analysis of duration dependence.

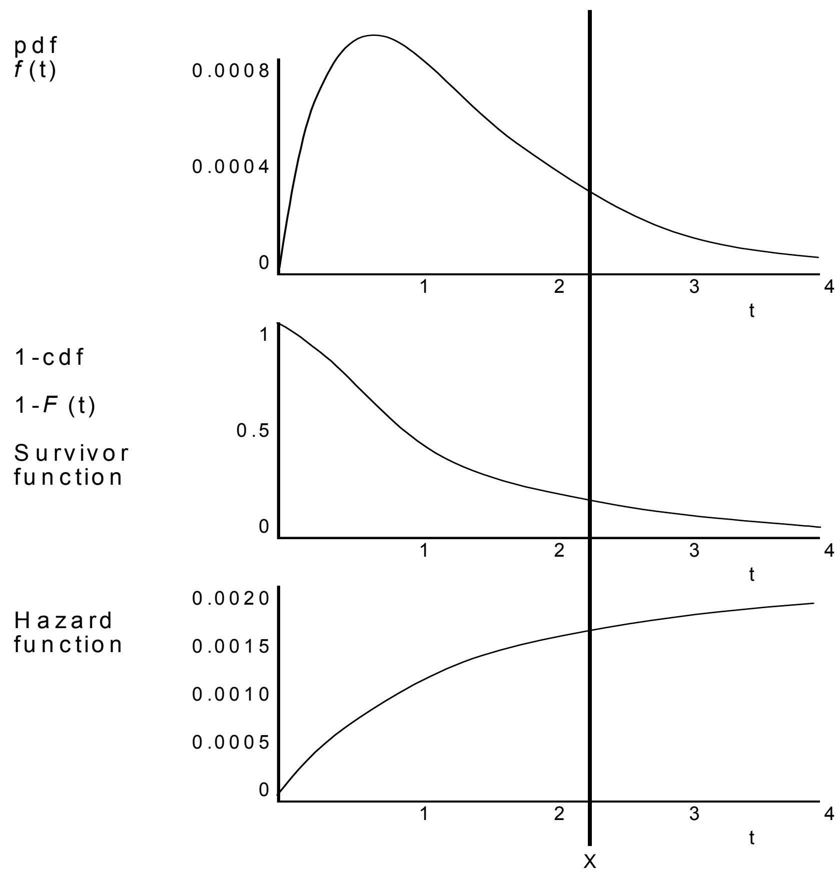


Figure 2: Examples of probability distributions from duration data

The hazard function is determined as:

$$\theta(t) = \frac{f(t)}{1 - F(t)} \qquad (3)$$

The hazard function is thus the probability distribution function divided by one minus the cumulative distribution function:

$$\theta(t) = \frac{pdf}{1 - cdf}. \qquad (4)$$

Figure 2 represents the three probability distribution functions, which can be derived from empirical duration data of unemployed workers.

In economics it is common to refer to the hazard function $\theta$ as the 'exit' or 'outflow' rate. In statistics the hazard function can have different shapes. Figure 3 represents different shapes the hazard function can exhibit.

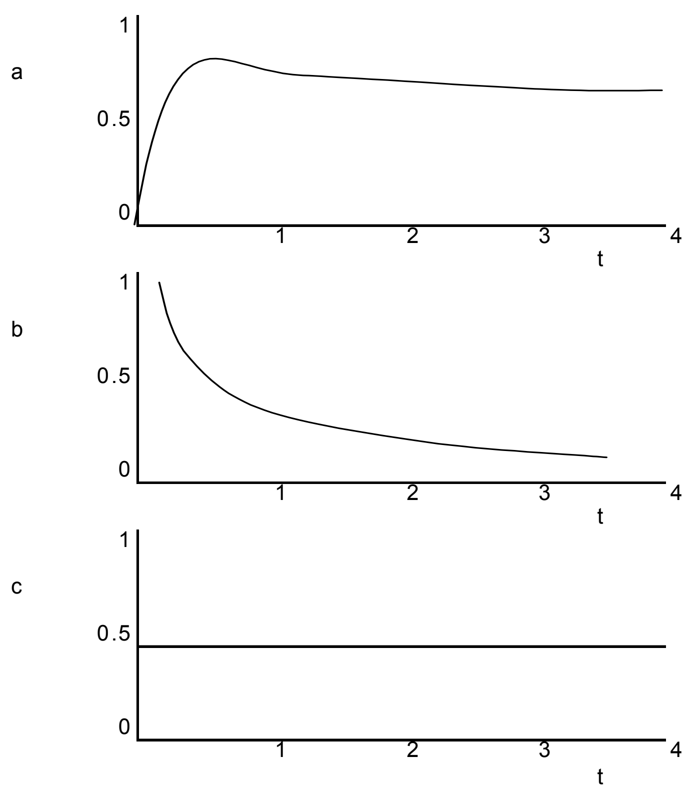


Figure 3: Three hazard functions

Source: Lancaster, 1990:10

Time dependency is absent when the hazard function is constant over time (as in figure 3c). In case of a decreasing hazard function (figure 3b) the population is "getting better" in staying in that state;[12] i.e. unemployment is negative duration dependent as the probabilities of leaving will collapse. Increasing hazard functions indicate positive duration dependency, meaning that the probability of leaving increases with duration.

So, in the approach suggested by Lancaster analysis of the from duration data unobservable reservation wage variable is replaced by the analysis of the hazard rate. This hazard rate can be derived from observable duration data and is taken as a sound proxy of the reservation wage. In the econometric model building process the central issue then becomes the finding of an appropriate specification of the outflow process.

In order to get a better understanding of this approach we will study the econometric specification Lancaster applied in his model in more detail.[13]

## 5 Lancaster's 1979 duration model

Lancaster demonstrates his method by calculations of the temporal variation of the chances of an unemployed to return to work, which obviously is duration dependent. His method became very influential and many other economists followed his approach. However, whereas some researchers like Narendranathan, Nickell and Stern (1985) follow a structural approach in order to establish the determinants of the duration of the spell of unemployment, Lancaster follows a reduced form approach, which he tried to give a 'structural interpretation'. Many structural duration models (like Narendranathan, Nickell and Stern) suffer from measurement difficulties at the structural form level due to identification problems and the use of reduced form is a classic econometric response to such difficulties.

In his model Lancaster distinguished two opposite time varying effects on the probability of outflow. Firstly, the effect of a declining reservation wage due to time varying unemployment benefit structure. And secondly, a decline in the arrival rate of jobs, which deteriorates the workers outflow probability. For Lancaster's model to work he now needs to specify the hazard. According to Lancaster the mathematically most attractive way to proceed is to reduce this set of variables to a function of time and a function of other regressor variables, *x* (Lancaster, 1979: 945). He specifies the outflow probability then as a function of observable characteristics (*x*) and time (*t*): [14]

$$\theta(t) = \psi_1(x)\psi_2(t) \qquad (5)$$

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[12] Again, the terminology is unfortunately rather counterintuitive here.

[13] A overview of this method can be found in Layard, Nickell and Jackman (1991) and Machin and Manning (1999)

[14] This implies that unemployed have the same time path of their re-employment probabilities, what in the literature is referred to as '*proportional hazards*'.

The most obvious function to use for the specification of $\theta(t)$ would be the exponential function. An exponential distribution however yields constant hazards rates and is therefore not very helpful in cases where we deal with duration dependence. The exponential distribution function however is a special case of a function known as the *Weibull distribution function*. The Weibull function is a function widely applied to reliability and life data problems. It is used often in biometrics, medicine and mechanical engineering for the analysis of life behaviour like the administration of a treatment, gaining weight after birth, the disappearance of symptoms, the ability to return to work, and duration of light bulbs or ball bearings, etc.[15] It is widely used in duration analysis of unemployment since the function can easily take duration dependency into account. The Weibull function can be expressed in different forms. In general it is written as:

$$\theta(t) = \lambda \alpha t^{\alpha-1} \qquad (6)$$

or $$\theta(t) = \exp(x,\beta) f(t) \qquad (7)$$

Lancaster specifies the conditional probability function $\theta(t)$ with a Weibull function for the time varying component of (5) as: [16]

$$\psi_2(t) = \alpha t^{\alpha-1} \qquad (8)$$

In equations (6) and (8) $\alpha$ represents the coefficient of duration dependence and $\beta$ is the vector of coefficients associated with *x*. We can think of $\beta$ as the elasticity of the hazard with respect to *z*. $f(t)$ represents the 'baseline hazard' and captures the variation of the outflow with duration. $\lambda$ is called the scale parameter, whereas $\alpha$ is called the slope parameter. It can easily be seen that the factor $t^{\alpha-1}$ (in equation 6 or 8) is responsible for the degree of duration dependence. The consequences of different values of $\alpha$ for the Weibull *pdf* and hazard rate are presented in figure 4 and 5.

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[15] W. Weibull originally established the function in 1937 in Sweden for the analysis of fatigue in ball bearings.

[16] The observable characteristics of $\psi_1$ are in Lancaster's model written as:

$$\log \psi_1 = \beta_0 + \beta_1 + \log AGE + \beta_2 \log UNEMPLOYMENT + \beta_3 REPLACEMENT$$

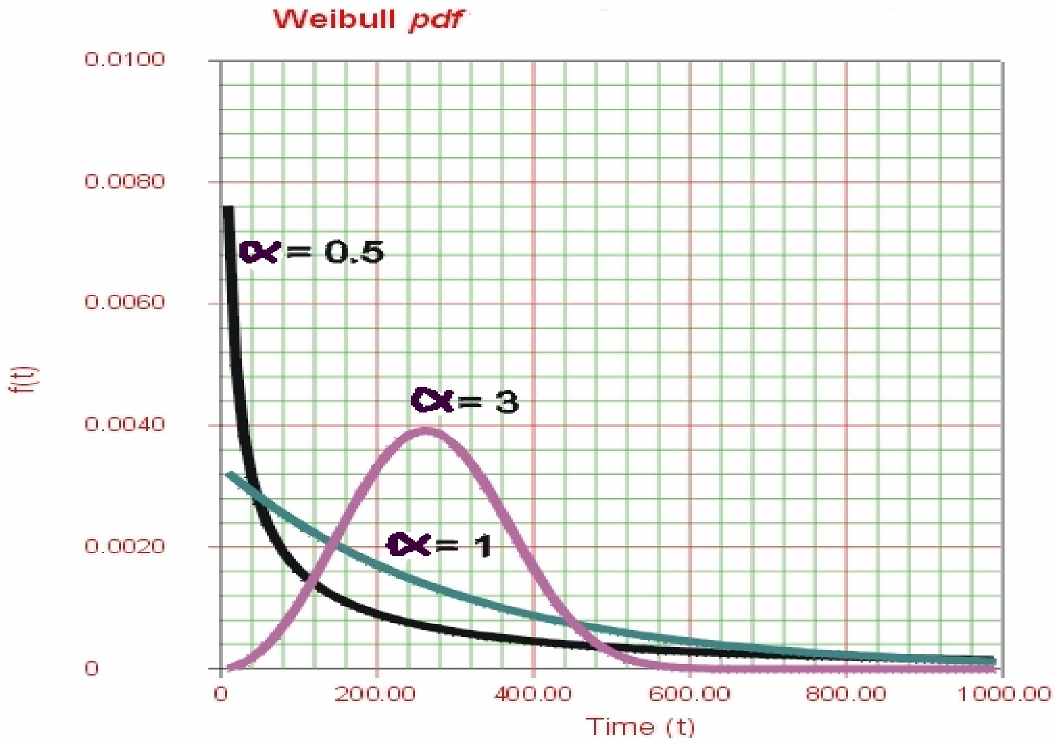


Figure 4: Weibull *pdf* with different values of $\alpha$

In the special case of $\alpha = 1$ there is no duration dependence. The Weibull function then will yield a common exponential function and the Weibull hazard rate (figure 5) will be constant (and identical to figure 3c). Values of $\alpha > 1$ determines positive duration dependence and hence increasing hazard rates; values of $\alpha < 1$ negative duration dependence and decreasing hazard rates (figure 5).

In economics it is assumed that the total outcome effect of duration on unemployment is negative and that $\alpha$ is therefore smaller than 1. In that case both the Weibull *pdf* and the hazard function are decreasing functions, which represent the decreasing probabilities for long term unemployed to find new employment. With his model Lancaster finds a value of $\alpha$ of 0.77, which indicates a negative duration effect of unemployment. Of the two opposite effects, the drop in the stream of job offers is the strongest and fails to be offset by a drop in the reservation wage (caused by a time varying unemployment benefit structure).

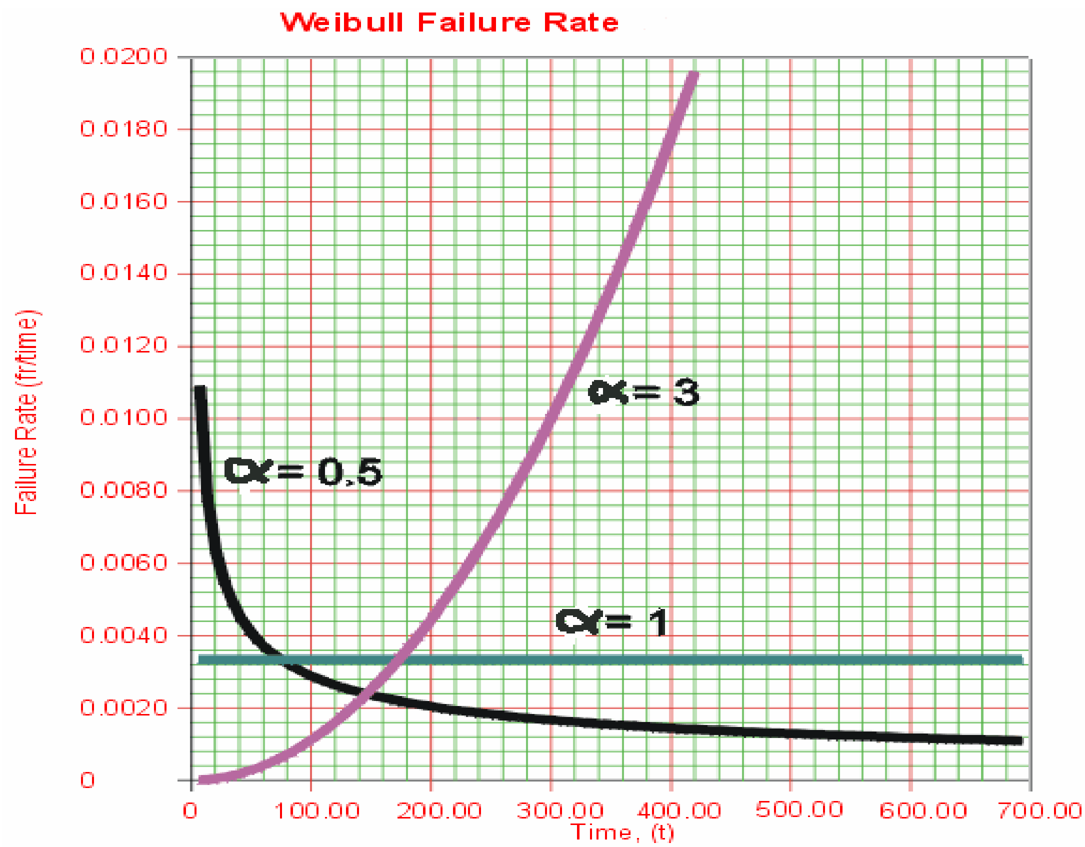


Figure 5: Weibull hazard rate with different values of $\alpha$

In the conclusions of his seminal article Lancaster casts some doubts about the method he suggests. In particular he worries about the arrival rate of jobs, as this rate is a function of the labour market tightness that is defined in terms of unemployment, and vacancies; variables we cannot control for. The arrival rate therefore might not be constant over time and influence the probability of leaving unemployment. Lancaster warns that: "It should be noted that studying $\theta$ is very much a second best to studying $\overline{w}$" [*the reservation wage, PR*] "itself since even though $1-F(\overline{w})$ is monotonic in $\overline{w}$, $\theta$ and $\overline{w}$ need not vary in the same direction over time due to the possibility of variation in $\lambda$, the rate at which opportunities of employment present themselves" (Lancaster, 1979: 941). Lancaster therefore concludes: "My own view is that the study of duration of unemployment data is probably not going to be a very helpful way of testing those predictions of search theory which concern themselves with the way individuals vary their reservation wage as the time passes" (Lancaster, 1979: 956).

## 6 Lancaster's duration model as a measuring device

Let's now see how Tony Lancaster's model constitutes a measuring device and analyse the model in terms of the triple, internal principles, bridge principles and calibration.

### 6.1 *The internal principles of the model*

The standard econometric textbooks approach to connecting theory to real world data looks something like this (figure 6).

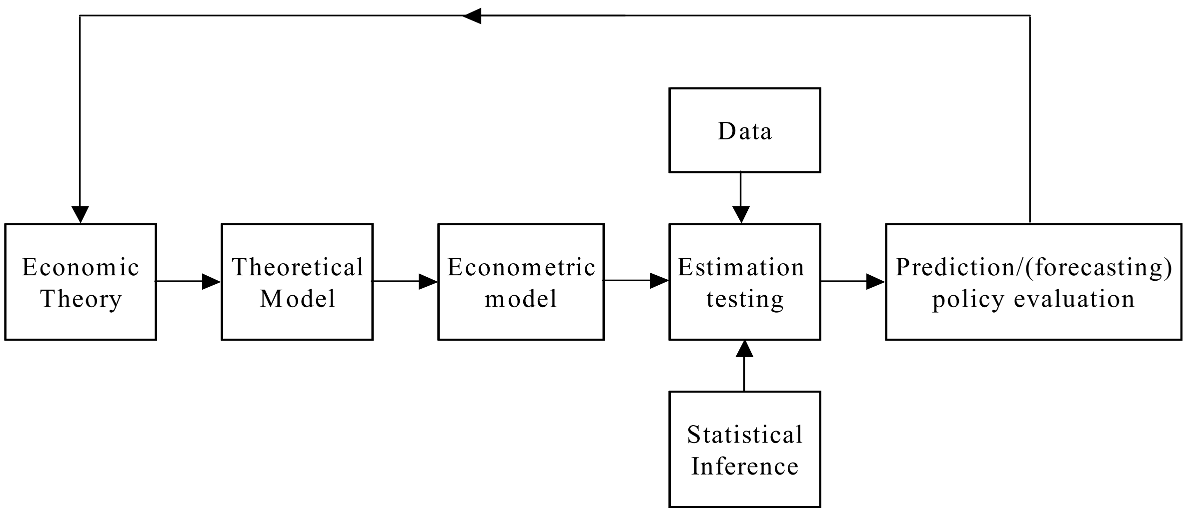


Figure 6: Textbook approach to econometric modelling
(Source: Spanos, 1986: 16)

A theoretical model is derived from economic theory and 'converted' into an econometric model where parameters are estimated and a white noise error term is added. That is to say, economic theory provides us with the structure of reality and when confronted with empirical data we can specify the strength of the relations.

Many authors, like for example Spanos (1986:15-22), have argued that this account is too simple and therefore to some extent misleading. Strong claims against this textbook account are made by Boumans (1999b). He shows from analysis of early business cycle models, that in order to let these model meet certain quality criteria, other ingredients than theory alone, have to be incorporated in the model a priori. Ingredients, such as metaphors, analogies, policy views, mathematical techniques and concepts and stylised facts, are taken into account in the design and building stage of the model and subsequently incorporated in the model. In this way it can be assured

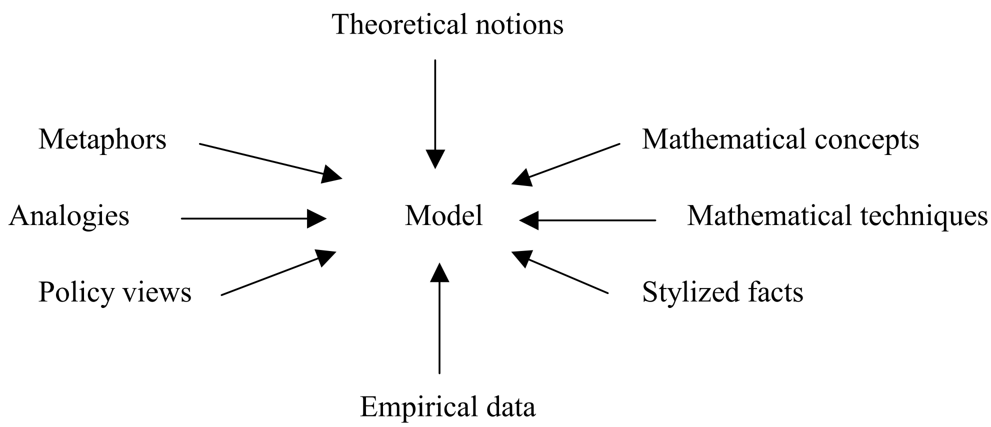


Figure 7: Boumans' built-in justification account of models
Source: Boumans (1999b) in: Morgan and Morrison: 1999, 93

that certain quality criteria are met after confronting the model with empirical data. Thus, to speak in Popperian language, the context of discovery and the context of justification are not separate processes in the economic practice of model building but they are inextricably intertwined. Boumans therefore argues that justification of the model is built-in a priori.

Cartwright also reckons that inevitably unrealistic elements have to be added in the construction of models. She argues that laws of nature (i.e. "claims about what necessarily or reliably happens") are scarce, and hard to get since we cannot always control disturbing influences. In her *simulacrum*[17] account of models (1983) she argues that models serve to represent the circumstances where laws arise. Within the special context of a model regular, lawlike behaviour can be generated, that can help us to locate laws of nature, i.e. regularities produced by highly structured arrangements, that she characterise as *nomological machines.* In this way models serve as blueprints for nomological machines. The unrealistic elements in the construction models come into play in tying down the models to data. Both internal principles and bridge principles are needed here and Cartwright stresses that they both are simplifications and have inevitably idealistic elements added. Some aspects of the model describe genuine properties, i.e. properties that are essential to the phenomenon but other aspects of the model are rather 'properties of convenience'.

One of the major differences between Boumans and Cartwright's account seem to be the way the bridge principles come about. In Boumans view model builders already have notions of how to model the phenomenon mathematically and accommodate these notions into the model when designing it; a process he refers to as '*mathematical moulding*' (1999b). In Cartwright's view the

[17] Simulacrum means 'something having merely the form or appearance of a certain thing, without possessing its substance or proper qualities' (Oxford English Dictionary)

bridge principles seem to follow from the internal principles but their status are just convenient, not necessarily true, expressions of internal principles.

Let's turn to the internal principles of search models now. Economic theory tells us that the driving principle (internal principle) of search models is the process of reservation wage determination (or cut-off price in case of the goods market) and the tendency of the reservation wage to go down (cut-off price to go up) for various reasons. The internal principles of the search models, however, relate to variables, like the reservation wage, which are unobservable from duration data. Duration data is relatively easily to obtain and economists consider for these reasons another internal principle to which they can apply this sort of data, namely the outflow process, as a replacement of the process of reservation wage adjustment. The behaviour of the main variables in the two mechanisms seems to be correlated in the sense they exhibit opposite behaviour. It can be observed from figure 1, but follows also from equation (1): $\theta_i = \lambda_i p(z_i)$. With a constant arrival rate $\lambda$, $\theta$ (hazard rate) and $z$ (reservation wage) move in opposite direction. Moreover, contemporary economists take the outflow process of unemployment as a stable process. Though unemployment obviously changes over aggregate demand cycles, the large majority of the labour force is employed. At a 5 % unemployment rate 95 % of the labour force employed. In addition, is the stock of unemployment is very small compared to total turnover (flow) in the labour market. Thus, though there are fluctuations in the unemployment rate they are small and show the labour market to be a regular working device. Viewed in this light the labour market itself can be considered as a nomological machine that generates a more or less regular behaviour (outflow) and the models that describe this process as their blueprints.

The case here at hand here also illustrates how the textbook approach to econometric modelling is an idealisation and shows that arbitrary, un-theoretical assumptions or decisions are needed. The theory used here, search theory, analyses the search behaviour of agents but provides only a broad framework. Rather, it covers a wide variety of search models that represent different allocation mechanisms in the labour market. The theory however is not helpful in all aspects of model building. For example, in search models the gains of a productive match have to be distributed between the worker and the firm. In the literature the function that describes this process of allocation of gains, is referred to as the 'sharing rule'. Search theory however is silent about how this function should look like and the fact that often an equal sharing is used is more likely explained by its ease of use and the fact that it results in Nash equilibria than that a solid theoretical foundation can be found.[18] Theory provides no compelling reason as to why the gains should be split equally. Other arbitrary decisions in model building include for example, on-the-job search, job duration etc. In Narendranathan, Nickell and Stern's model (1985) the valuation of leisure is left out, since the marginal utility of leisure is likely to vary with the personal characteristics *x*. Narendranathan, Nickell and Stern argue that "arguments of this kind are one of the reasons why it is difficult to identify structural models of search behaviour without making arbitrary prior assumptions." (Narendranathan, Nickell and Stern, 1985: 311). It will be clear that some properties describe some real properties of the modelled object. Other properties however are pure works of fiction, idealisations.

### 6.2 *The Weibull function as a bridge principle*

The internal principle is made operational by imposing a Weibull specification on the hazard function. In this way the Weibull function functions as a bridge principle as it bears on the relation between the model (outflow process) and the mathematical representation. In the Logical Positivists tradition from which this account of internal principles and bridge principles stems, a strict isomorphism between the model and the world is required. That is, essential elements and relations of the phenomenon must be mapped one-to-one to elements and relations of the model, which at their turn must be referable to direct observations. In this way the mathematical equation serves as a correspondence-as-congruence rule, which is established in order to express theoretical terms in direct observational terms. This view requires that the Weibull function is a true and exact description of the outflow process of the labour market. This claim however seems much too strong. The outflow process could be described by a whole set of other distribution functions like the log-normal, Gompertz, Inverse Gaussian, generalized F and Gamma distributions, etc. There are no compelling reasons for using the Weibull function other than that it functions well over a wide variety of cases. The other distributions mentioned might be useful only in specific circumstances (Kiefer, 1988:655).

Cartwright's interpretation of bridge principles as abstractions therefore seems more appropriate.[19] The representation is not necessarily a true one and the bridge principles are rather conventions. Bridge principles are not necessarily true, but must work well in a great variety of cases. They are chosen for their convenience since we do not want to develop a bridge principle for each unique situation. As Nancy Cartwright puts it: "the 'right kind of description' for assessing an equation is seldom, if ever, a 'true description' of the phenomenon studied; and there are few formal

[18] See for example Diamond (1982)
[19] Her account seems more akin with the *semantic* account of models, which considerers models representations.

principles for getting from 'true descriptions' to the kind of description that entails an equation. There are just rules of thumb, good sense, and, ultimately, the requirement that the equation we end up with must do the job." (Cartwright, 1983: 133). The widespread use of Weibull functions in order to operationalise search theory seems only to be inspired by its convenience of use and the belief that the function does the job quite well, i.e. that the Weibull function exhibits decreasing hazard rates. And it is exactly this what Nancy Cartwright calls *real* bridge principles. "To do quantum mechanics, one has to know how to pick the Hamiltonian. The principles that tell us how to do so are the real bridge principles of quantum mechanics" (Cartwright, 1983: 136). Or analogue, the principles that tell us how to pick the right equation for the hazard are the true bridge principles of search theory.

### 6.3 *Calibrating the model*

Finally, as a last step in the measuring procedure, the Weibull function has to be calibrated. That is, adjust the model parameters in such a way that the model fits the empirical data well. Since we want the model to reveal negative duration dependence the value of $\alpha$ is necessarily limited to values smaller than 1. After calibration two things have been accomplished. In the first place, the outflow process is presented as an invariant generalization. The Weibull function, which was chosen for its convenience, turned out to be very sensitive to its parameter values (as can been seen in figures 4 and 5), but calibration fixed the parameter value and the function becomes robust over a wide variety of circumstances and independent of disturbing factors. Secondly, the parameter value provides the rate of duration dependency we were after.

Unfortunately, a serious problem arises in calibration of $\alpha$, which is inherent to this measurement procedure of duration dependence. In his seminal paper Lancaster already points out to the problem of *unobserved heterogeneity*. The problem is that if we observe decreasing probability of outflow associated with duration is the cause than *'true'* duration dependence, or is the phenomenon caused by other variables that are not observable to the researcher? Unobservable variables like the workers mental state or work attitude are not captured in data sets but might account for LTU as well. So, in short the problem is: is duration dependence the cause of LTU or is it something else? Economists try to deal with this problem in the following way.[20] The Weibull function for the hazard (equation 7) is re-specified as:

$$\theta(t) = \upsilon \exp(x, \beta) f(t) \qquad (9)$$

[20] An overview of the existing literature that deals with this problem can be found in Machin and Manning (1986: 3107-3111).

where $\upsilon$ is the variable that captures all unobserved variables, like work attitude, motivation, mental state, etc. It basically means that we write $\theta$ as a function of a set unobservables ($\upsilon$), observables ($x$) and time ($t$). Next a distribution for $\upsilon$ is specified: $H(\upsilon)$. This is considered as an 'error' distribution and is usually taken as a Gamma function. It is then possible to determine the duration dependency by imposing restrictions on the functional form. The fundamental problem with this method is thus how to discriminate between duration dependency $\alpha$ and unobserved heterogeneity $\upsilon$. This manifests itself as the problem how to model the baseline hazard $f(t)$ and the 'error' function $H(\upsilon)$. Identification of equation (9) is possible only by making specific and un-theoretical assumptions about the baseline hazard and the 'error' function and the assumption of mixed proportional hazards; the assumption that $\upsilon$ is strictly independent from $x$ and $t$. Lancaster puts it: "identification can be achieved when certain functional form restrictions can be assumed. Unfortunately these functional form restrictions generally have little or no economic-theoretical justification. There is no known economic principle that implies that hazard functions should be proportional …still less does economic theory imply Weibull models" (Lancaster 1990: 157). Machin and Manning therefore conclude that: "It does not really seem possible in practice to identify separately the effect of heterogeneity from that of duration dependence without making some very strong assumptions about function functional form which have no foundation in any economic theory". (Machin and Manning, 1999: 3111). So, unfortunately for the measurement of duration dependence, the measurement procedure runs into trouble as a consequence of another unobservable or not easily accessible variables

## 7 Conclusions

In logical Positivist philosophy of science the path from theory to data is taken as a top down process that runs as:

Theory $\Rightarrow$ Internal principle $\Rightarrow$ bridge principle $\Rightarrow$ (direct) observations

The stance seems to be that once we have established the internal principle(s) from theory, the bridge principle(s) will easily follow as we can always find a convenient mathematical expression that fits the internal principle and data well. In economic science models often function as mediating devices between theory and data (Morgan, 1999), and they constitute both internal principles and bridge principles. The representational theory of measurement requires for sound measurement a strict isomorphic mapping between an empirical relational structure and a numerical relational structure.[21] In economic models the internal principles, which are simplifications of essential structures in the world and which have proven to be more or less stable, (or in any case stable enough) over a variety of circumstances can realised this isomorphic mapping. As such models can be used as measuring instruments. The internal principles are expressed in convenient and not necessarily true mathematical descriptions, the bridge principle. Finally, since the internal principles of a model may be inexact and inaccurate due to disturbing factors they can be transformed into exact and accurate relationships by calibration. For measurement by models thus the triple internal principle, bridge principle and calibration is required.

The idea of a top down path from theory to data is also underlying the textbook approach to econometric model building. The case at hand shows that this account is not completely appropriate here. The problem to begin with is that there is an insuperable theory – data gap. The driving force in search theory, which forms the internal principle of search models, is adjustment of the reservation wage (or price) of heterogeneous workers, i.e. with differences in productivity, valuation of leisure, information, etc. However, there appeared to be no real world data that could be applied to search models in order to make the crucial variables in the model, such as the reservation wage or flow utility, observable to the researcher. In addition, search theory does not provide us with strategies for making the theory operational. Data of duration of unemployed on the other hand is relatively easy to obtain from, for example surveys, and the statistical methods for analysing it are well known from biometrics and mechanical engineering. The innovative aspect of Lancaster's approach appears thus to be the replacement of the internal principle for an entirely different framework; that of the outflow process of unemployment. Contemporary economists consider the outflow out of unemployment as a relatively stable process; i.e. only a small fraction of the turnover in the labour market is unemployed, and this fraction is more or less stable over different circumstances. In addition, this process it associated with reservation wage setting, the internal principle of search theory. The step from a theoretical economic model to an econometric model isn't simply a matter of 'filling in' the parameters. Key variables in the economic model are completely absent in the econometric model, and instead, a completely different mechanism is operationalised in order to analyse the implications of search theory. In this case the path from theory to data appears to a bottom up process: available data drives the search for an intern principle that is more or less consistent with search theory.

[21] See for example Suppes, P. and Zinnes J.L. (1963).

As a consequence of this ‘internal principle shift’ duration models of unemployment cannot test the behavioural implications of search theory, a point well taken by Lancaster. Theoretical explanations take place in the domain of search theory. In curve fitting the outflow process there is nothing that gives rise to an explanation of behaviour of economic agents or even the phenomenon of a regular outflow. So, where search theory tries to provide an explanation for the fact why there is still unemployment even when supply and demand for labour are equal (the natural rate of unemployment), the duration models do not so. Nevertheless, they can be used for measurement.

Finally, the case of measurement of duration dependence the measurement procedure depends critically on the establishment of an appropriate mathematical representation of the outflow process. Out of a set of possible functions the Weibull function is chosen for reasons of ease and the fact that it provides decreasing hazard rates. As shown there are no compelling economic reasons for using this particular function, nor are there reasons to belief it corresponds to real world outflow processes of unemployment. The Weibull function just does the job of measuring duration dependence and therefore it serves as a *real* bridge principle as Nancy Cartwright puts it. However, as consequence of unobserved heterogeneity (the fact that LTU might be attributed to a characteristic unobservable to the researcher), duration analysis of unemployment runs into trouble. By imposing strong restrictions and assumptions upon the used specification it is possible to get measures of duration dependence but they turned out to be very sensitive to the precise specification of the Weibull function and the underlying assumptions. So, if one is to rescue duration analysis untheoretical assumptions have to be made for which even the principle of convenience for bridge principles cannot be helpful. Thus while the analysis of duration data was set up in the first place to circumvent the problem of making an unobservable explanatory variable operational, new unobservable variables emerge in this approach that prevent this method from being fully satisfactory.

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*7,461 words*

## References


Albrecht, J. W. and Axell, B. (1984), An Equilibrium Model of Search Unemployment, *The Journal of Political Economy*, vol.92, no. 5, p. 824-840

Bailer-Jones, D. M. (2002), It is still mechanisms that make us understand, working paper

Boumans, M. (1999a), Representation and Stability in Testing and Measuring Rational Expectations, *Journal of Economic Methodology*, vol. 6, no. 3, p. 381-401

Boumans, M. (1999b), Built-in Justification, in: Morgan, M. S. and Morrison M. (eds.) (1999), *Models as Mediators*, Cambridge University Press

Boumans, M. (2001), Measure for Measure: How Economists Model the World into Numbers, S*ocial Research*, vol. 68, no.2, summer

Boumans, M. (2002), *How Economists model the World into Numbers*, Routledge, 2005

Cartwright, N. (1983), How the Laws of Physics Lie, Clarendon Press

Cartwright, N. (1999), The Dappled World, Cambridge University Press

Diamond, P.A. (1982), Wage Determination and Efficiency in Search Equilibrium, *Review of Economic Studies*, Vol. 61, Issue 3, 457-475

Diamond, P. (1998), Search Theory, in: Eatwell, J., Milgate M. and Newman, P. (eds), *The New Palgrave Dictionary of Economics*, Macmillan Press Ltd. London

Ellis, B. (1966), *Basic Concepts of Measurement*, Cambridge University Press, Cambridge

Flinn, C. J. and Heckman J., (1983), Are Unemployment and Out of the Labor Force Behaviorally Distinct Labor Force States? *Journal of Labor Economics*, Vol. 1, No. 1. pp. 28-42.

Gibbard, A. and Varian, H. (1978), Economic Models, *Journal of Philosophy*, vol. 75, p 664-77

Hansen and Heckman, J., (1996), The Empirical Foundations of Calibration, *Journal of Economic Perspectives*, vol. 10, no.1, pp87-104.

Hempel, C.G., (1966), *Philosophy of Natural Science*, Prentice-Hall

Heidelberger, M. (1994a), Alternative Interpretationen der Reprasentionstheorie de Messung, in: Meggle, G. and Wessels, U.(eds.), *Analyomen 1, Proceedings of the 1st Conference "Perspectives in Analytical Philosophy*", Walter de Gruyter, Berlin

Heidelberger, M. (1994b), Three Strands in the History of the Representational Theory of Measurement, Working Paper, Humbolt University Berlin

Kiefer, N.M. (1988), Economic Duration Data and Hazard Functions, *Journal of Economic Literature*, Vol. 26, no. 2, p.646-679

Lancaster, T. (1979), Econometric Methods for the Duration of Unemployment, *Econometrica*, vol. 47, no. 4, p. 939-956

Lancaster, T. (1990), *The Econometric Analysis of Transition Data*, Cambridge University Press

Layard, R., Nickell, S. and Jackman, R. (1991), *Unemployment, Macroeconomic Performance and the Labour Market*, Oxford University Press

Machamer, P., Darden, L. and Craver, C. (2000), Thinking about Mechanisms, *Philosophy of Science* 67, pp. 1-25

Machin, S. and Manning, A. (1999), The Causes and Consequences of Long-Term Unemployment in Europe, *Handbook of Labor Economics*, vol. 3, p. 3085-3139

Morgan, M. S. (1985), Finding a Satisfactory Empirical Model,

Morgan, M. S. (1998), Models, in: (Davis, J.B., Wade Hands, D. and Maki, U, eds.), *The Handbook of Economic Methodology*, Edward Elgar, Cheltenham, UK

Morgan, M. S. and Morrison M. (1999), Models as Mediating Instruments, in: Morgan, M. S. and Morrison M. (eds.) (1999), *Models as Mediators*, Cambridge University Press

Morgan, M.S. (2001), Models, Stories and the Economic World, *Journal of Economic Methodology*, vol. 8, no. 3, p. 361-384

Narendranathan, N., Nickell, S., Stern, J. (1985), Unemployment Benefits Revisited, *The Economic Journal*, Vol. 95, no. 378, p. 307-329

Spanos Aris, (1986), *Statistical Foundations for Econometric Modelling*, Cambridge University Press

Suppes, P and Zinnes, J.L. (1963), Basic Measurement Theory, in: Luce, R.D., Bush, R.R. and Galanter, E. (eds.), *Handbook of Mathematical Psychology*, vol 1., New York, Wiles, 1-76