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MEASURING STOCKS AND FLOWS OF HUMAN RESOURCES FOR SCIENCE AND TECHNOLOGY (HRST); A SURVEY OF METHODS

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Abstract

The paper presents available definitions for the measurement of Human Resources for Science and Technology (HRST) stocks as well as a summary of methodologies employed for an understanding of their mobility. The paper begins with an outline of definitional and concordance issues relating to the counting of HRST stocks. A discussion of methods for measuring and explaining mobility then follows. A brief link to existing data sources for Ireland is also made, highlighting promising areas for applications.
1. Introduction

The paper presents available definitions for the measurement of Human Resources for Science and Technology (HRST) stocks as well as a summary of methodologies employed for an understanding of their mobility. Human resources impinge on the success of all stages of the innovation process, including the generation of new technologies as well as their diffusion and use. The study of innovation from a systemic perspective, as expressed in the works of Lundvall (1992) and Freeman (1995) regards knowledge an important resource. As such, individuals are seen as retainers and carriers of knowledge, particularly non-codified knowledge obtained by operational experience. By extension, human resource mobility is thought a key instrument for the communication of knowledge of this kind (Lundvall, 1992). Naturally, not all tacit knowledge will be equally useful in the production of technology and the associated needs of an ‘information economy’. Individuals educated or otherwise skilled in certain fields should have a greater impact on the innovation system. In a narrow sense, these groups are thought of as those qualified in the realms of science and engineering, reflecting the prominence of technical innovations.

The presence of a highly skilled HRST workforce in Ireland has long been recognised as a key enabler for the development of its national innovation system (Healy, 1983; HEA, 2002; DETE, 2004). However, Ireland’s traditionally high investments in human resources (in terms of years of schooling) are not what set the country apart internationally. The so-called ‘Celtic Tiger’ was made possible, in part, thanks to what, (one can now judge with hindsight) were appropriate qualitative adjustments in education (Wickham and Boucher, 2004). It is now acknowledged that the ability of policy makers to anticipate and meet future labour demand in key industries may determine the sustainability of Ireland’s prosperity and the dynamism of its national innovation system (HEA, 2002, ESG, 2004). Hedging bets on future techno-economic trajectories is a difficult enough business. Assuming for a moment that one gets it right, the success of any attempt at aligning the supply of labour rests not only with information on the availability of sufficient stocks but also with the extent, implications of and factors affecting labour mobility. To the extent that highly qualified researchers could be described as inputs to the innovation system, their generation by means of formal training and operational learning is only a first (necessary) step towards making them available to industry. Given Ireland’s continuing sectoral shift, the propensity of its HRST workforce to change jobs or relocate could prove crucial to its long-term ability to benefit from technical change. In that sense, the factors influencing the extent of labour flows would be of great interest to policy makers. At present there is no country-specific study of HRST mobility in Ireland; by presenting relevant methods and linking them with some available data the author hopes to highlight viable opportunities for analysis.

A series of pioneering studies of Nordic countries (Denmark, Finland, Norway and Sweden) performed by the STEP\(^2\) group have made significant contributions to the area (Hauknes, 1994; Nås, 1998; Ekeland, and Ørstadvik, 2001; Hauknes and

\(^1\) Although tacit knowledge can also be communicated through organisational linkages and the diffusion of knowledge embodied in technological products, the mobility of staff is seen as the main channel (OECD, 1997).

\(^2\) Studies in Technology Innovation and Economic Policy
Ekeland, 2002; Virtaharju and Åkerblom, 2003). To the best of the author’s knowledge, these were the first to look at the mobility of HRST, influenced undoubtedly by the contemporary emergence of innovation systems theory. Nevertheless, the systematic study of labour mobility in an innovation context is a very recent development, and attempts to measure and model the mobility of HRST (with the novel element of knowledge retention and communication) are still at a formative stage. Therefore, in addition to studies with a knowledge component, the present survey looks into long-established approaches to modelling labour mobility or as is otherwise termed ‘turnover’\(^3\) (Brissenden, 1920; Hall, 1972; MacDonald, 1988). These approaches have not only measured mobility but have also shown it to be associated with changes in unemployment (Hall, 1972), industrial structure (Bull and Jovanovich, 1988) and manifested productivity (Ilmakunnas et al., 2005).

2. HRST Stocks & Flows: Definitions & Scope

Defining HRST

Attempts at defining social phenomena frequently entail the creation of a layer of abstraction that distances itself from what could be rightly construed as reality. Definitions involve, to a varying extent, a remodelling of reality to suit the purposes of analysis; inevitably a whole new language (or ‘metalanguage’) of meticulously crafted terminology is needed to achieve the level of reduction necessary for conceptualisation. The study of human knowledge, its communication, accumulation and original creation employs a metalanguage fraught with significant reductionist concessions. Terms like science, technology, knowledge and mobility take a meaning that is variably narrower or broader than what one would encounter in a dictionary. The study of mobility of highly skilled workers, particularly those which affect directly the innovation process rests on an edifice built with such terms. Our inability to readily observe and measure the actual state of affairs and the consequential reliance on proxies (e.g. educational qualifications as a proxy for knowledge) compounds this problem. Therefore, defining what is meant by Human Resources for Science and Technology (HRST) is far from stating the obvious. If we expect any conclusions drawn from the study of mobility to survive, overall, the return trip to reality, an explicit mapping of who should be counted in the HRST workforce is extremely important. Keeping in mind the definitions and the particular scope chosen in any given study of HRST stocks, and potentially mobility, is paramount to a valid interpretation of its results.

Modern societies rely on a wide range of technological competencies. There are different specialisations entailed in the operation of production machinery and the maintenance of an aircraft turbine, and yet altogether different specialisations involved in the discovery of a new mathematical axiom and the invention of a new computer processor\(^4\). The distinction employed most frequently is between persons who possess adequate knowledge to support the technological processes (i.e. technical

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\(^3\) Terms used interchangeably in literature.

\(^4\) Mokyr (2002) delineates between discovery and invention by referring to innovations resulting from the former as ‘Pasteur-type’ and the latter as ‘Edison-type’.
support staff or simply ‘technicians’) and persons who expand the body of human knowledge (i.e. ‘innovators’) (OECD, 1995). Analysts realise of course that such a distinction may not be always appropriate (Ekeland and Ørstadvik, 2001). It would not be impossible for a support technician to come up with an invention, although it would probably be unlikely.

In a broad sense the HRST workforce could be thought of as comprising of human resources possessing knowledge that enables them to participate directly in the support and development of basic science and applied technology. Qualifying knowledge for inclusion into the HRST workforce could be attained either by formal education or by the experience gained in and implied by innovation-related employment. The definition of HRST outlined in the OECD’s Canberra Manual (OECD, 1995) is the convention prevalent at present. Accordingly, the HRST workforce is defined as the sum of individuals fulfilling one of the following conditions;

(a) Successfully completed education at the third level in a S&T field of study;
(b) Not formally qualified as above, but employed in a S&T occupation where the above qualifications are normally required (OECD, 1995: §49).

As a first step in counting HRST stocks then, one would have to look into educational qualifications in the natural sciences and engineering. In the interest of uniformity and comparability across studies and countries the Canberra Manual recommends using the conventions established in the International Standard for the Classification of Education (ISCED). It is not helpful however that the Canberra Manual bases its formal education categories on an implementation of ISCED (ISCED’76) that is now outdated (superseded by ISCED’97) and is not used for data collected later than 1997. Whereas the Canberra Manual differentiates between technicians and innovators on the basis of sub-degree and first-degree level qualifications, such a distinction is absent from the new implementation of ISCED (UNESCO, 1997), thus presenting us with a potential difficulty in accounting for technicians. The approach of ISCED’97 is to (arguably more appropriately) single out technicians on the basis of the nature rather than the level of their qualifications. ISCED’97 distinguishes between third level degrees, which are practical, technical or occupation specific (ISCED classification 5B) as opposed to degrees, which are theoretical based, or research preparatory (ISCED classification 5A). Additionally, ISCED’97 classification 6 refers to research qualifications such as doctoral degrees, an important part of the innovators group. Hence, when dealing with post-1997 data a comprehensive accounting of the HRST workforce would include those with qualifications falling under ISCED 5B, 5A and 6 (UNESCO, 1997).

Technological competencies translate into concomitant technologically oriented professions even in the absence of formal educational qualifications. Performing one’s duties in a S&T profession involves learning by doing, using and interacting (Lundvall, Lorenz and Drejer, 2004). A person’s profession stands as accurate proof

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5 The use of this distinction, as many others, is justified by the fact that, on the whole, exceptions like the above are massively overwhelmed by a majority of cases when this distinction is valid.

6 The Canberra Manual (OECD, 1995) makes a distinction between core (natural sciences, engineering and technology, medical sciences, agricultural sciences and social sciences) and extended (humanities and others) fields of study.
of initial competence to enter the profession and also signals operational experience. Therefore a person’s past, current or future occupation is an adequate proxy of useful tacit knowledge. The Canberra Manual singles out specific professions for inclusion in HRST, using the International Labour Organisation’s (ILO) formal occupational classification, the International Standard Classification of Occupation (ISCO) (OECD, 1995; ILO, 1988). These professions include ‘Legislators, Senior Officials and Managers’ (ISCO Major Group 1), ‘Professionals’ (ISCO Major Group 2), ‘Technicians and Associate Professionals’ (ISCO Major Group 3), other S&T occupations (ISCO Major Groups 4-9) and those employed in the armed forces (ISCO Major Group 0) (OECD, 1995: 47). There are admittedly a number of problems with using the ISCO classifications for the counting of HRST stocks, including occupation types which without clarification obscure the true nature of S&T knowledge (e.g. teachers), double counting due to persons having more than one job and significant variations across statistical jurisdictions (e.g. in the counting of managers; OECD, 2001). The Canberra Manual provides suggestions for dealing with such problems, while allowing some leeway for study-specific variations. Inevitably special exceptions or inclusions of qualifications will be demanded by context-specific considerations. As a rule of thumb, the stock of ‘innovators’ would include occupations falling under ‘Professionals’ (ISCO Major Group 2), broadly matched to ISCED’97 categories 5A and 6. In a similar fashion, ‘technicians’ can be counted as those falling under ‘Technicians and Associate Professionals’ (ISCO Major Group 3), loosely matched to ISCED’97 category 5B.

Defining mobility

The meaning of the term mobility in labour economics is not confined to its strict lexical sense, that is a movement in space, but also extends to any employment-related ‘change of state’. In a wide sense, the ILO defines it as movements into and out of employment. For the purposes of mapping HRST mobility though, one has to adopt a narrower definition, in line with the underlying assumption of knowledge communication. Tacit knowledge can be acquired in previous employment and as such HRST mobility is about a given change of state within employment, ignoring the possibility of intervening unemployment states.

HRST mobility takes various dimensions. At the firm-level, movements of staff from one contractual employment arrangement to another (whether intra-firm or inter-firm) are termed job-to-job mobility. Becker (1964) places great importance on the effects of on-the-job learning for the accumulation of firm-specific knowledge. Employees moving within, or across firms introduce past experience to the stock of knowledge they encounter in their new assignment. The assumption is, that given the presence of conditions conducive to learning, the receiving plant or firm will absorb this knowledge input and enhance its innovative competence. Inter-firm mobility is a crucial mechanism for the diffusion of knowledge across an economy; the successful adoption of new technologies as well as an overall building of an organisation’s research capacity hinges on the transfer of tacit knowledge that has industry- or economy-wide applicability. A company could obtain such generic knowledge either by investing in worker training or by hiring already skilled staff externally. In turn, intra-firm mobility also has important learning implications for the individual as well
as the firm. Mobility of workers from one plant to another contributes to the transfer of firm-specific useful knowledge, exhibits greater potential for interactive learning\(^7\) (Tomlinson and Miles, 1999) and promotes the harmonisation of operations within a company. For all their benefits, immediate and residual, both types of job-to-job mobility exhibit significant costs in terms of loss of knowledge, the disruption of operations as well as the loss of diversity.

**Sectoral mobility** is also important for the maximisation of learning within an innovation system. Moving from one industrial sector to another could result in the remodelling and reapplication of knowledge, yielding competitive advantages in a particular niche. Moreover, it could act as a conduit for the transfer of technology from technology-producing industries to technology-consuming ones. For example, to the extent that most technical innovations occur in the manufacturing sector, the movement of experienced human resources out of this sector and into services could prove pivotal to the diffusion of general purpose technologies. In periods of rapid structural shifts, sectoral mobility is important for maintaining a steady supply of skilled labour (Tomlinson, 1999). Depending on the context of the study either the ISIC\(^8\) or NACE\(^9\) classifications for industrial sectors are used, with NACE being the established format for studies in EU countries.

**Institutional mobility**, that is movements of individuals to and from government, industry and academia has also important learning and communication implications. At its commonest, institutional mobility may involve one-off transitions from education to employment. Less common are random flows among actors. Mobility from basic research institutions to firms may contribute significantly to the firm’s knowledge base, its technological scanning abilities as well as the efficacy of outsourcing. Mobility in the opposite direction, from private companies to basic research institutions, may lead to a greater number of commercially useful discoveries and inventions (Lorenz, 2004). The view that there are potential gains to be had from institutional mobility is currently gaining recognition; recent policy-oriented documents by the European Commission and the OECD identify a number of obstacles to these flows and recommend corrective action (CEC, 2004; OECD, 2004).

Finally **geographic or spatial mobility** is a dimension of significance. The tendency of individuals to move within a state’s borders could prove decisive to regional and local economic development. Efficient regional innovation systems are characterised by firm agglomerations often referred to as ‘clusters’. Regional clusters of firms could only emerge given the availability of labour with appropriate skills. If these clusters also represent agglomerations along sectoral or technological lines, then the specific skew of labour skills they demand is unlikely to be prevalent among residents in the immediate locality; for that reason their development is further conditioned by labour flows. International HRST flows can also complement skills shortages, whether at the

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\(^7\) Tomlinson and Miles (1999) argue that learning occurring as the result of intra-firm HRST flows is more likely to be dynamic as individuals are fusing their own knowledge with that encountered in the destination and learning occurs at both sides. To contrast with, inter-firm mobility may result in more static learning as it involves the transfer of knowledge that is not specific to the firm and requires only minimal adjustments, if any.

\(^8\) International Standard for Industrial Classification

\(^9\) Acronym from the French ‘Nomenclature statistique des activités économiques’, (statistical nomenclature for economic activities).
regional or sectoral level. Frequent flows of HRST across national borders may favour the transfer of knowledge from different national contexts and facilitate international networking. Country specific factors such as relative wages, national immigration policies and general attitudes towards foreign workers all influence the immigration and emigration of HRST.

3. Measuring & Explaining Mobility

The various methods employed for the analysis of labour mobility differ substantially in their aims and sophistication. Simple measurement of human resource flows is of value in its own right, for comparisons and context-specific policy. There is arguably greater value though, in linking measured mobility with contemporaneous changes in other economic variables. This can be achieved by setting out the underlying mechanisms in terms of an explanatory model. Econometric estimation is a two-stage process, where the results from measurement are fed into a model attempting to define relationships and identify explanatory factors.

Measurement Methodology

Ideally, one should be able to track the career progression of any given individual across time, from school to employment, from one job to another and so on. To the extent though that current data rely on surveys that do not follow the progression of the same individuals across time, but are based on regularly alternating random samples, only an approximation of life-long career paths is possible. Researchers are often forced to use data that was not purpose-generated and in response have created models incorporating creative adjustments. Inevitably, relevant techniques have emerged that measure what is measurable, rather than what would be required for a holistic analysis of mobility.

In measuring the mobility of HRST, achieving a socially optimal balance between benefits for the recipients and costs for those organisations that employees move out of, is a central question. Attempts to measure mobility make an important distinction between ‘in mobility’ and ‘out mobility’ (Virtaharju and Åkerblom, 2003), which are regarded as a benefit and a cost respectively. The OECD (2001) defines in mobility as the number of individuals who started a new job between time t-1 and time t (indicating gain for the receiving organisation). Conversely, out mobility is defined as the number of individuals who are leaving a job between time t and time t+1.

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10 A distinct possibility exists here in the analysis of census data; however most countries do not collect employment related information indicating ‘changes of state’. While, census surveys are certainly a promising way of measuring stocks, the large intervals between them limit the potential of their use for the measurement of mobility.
11 Also referred to in literature as accession rate (Brissenden, 1920) and inflow (Virtaharju and Åkerblom, 2003).
12 References to separation rate (Brissenden and Frankel, 1920), exit rate (Hall, 1972) and outflow (Virtaharju and Åkerblom, 2003) refer to the same measure.
13 Assuming an organisation characterised by effective knowledge communication and learning, even staff flows resulting in a net gain of zero, are preferable to no flows.
(indicating loss for the originating organisation). Although one could express flows of individuals in absolute numbers, a more meaningful measure would be an expression of flows as a proportion of the HRST total. Hence, mobility rates are commonly expressed in terms of percentages. For a given time period, such mobility rates yield widely intelligible statements on the probability of a worker to move from one job to another. This appears to be the preferred measurement method for aggregate level data, employed for cross-country comparative studies conducted by the OECD (OECD, 2001) and Eurostat (Lafia and Stimpson, 2001).

Derived percentages of in mobility or out mobility as a total of the HRST workforce are in effect probabilistic statements and can thus be counted as resulting from a normative ‘model’. Implied in such a model is the presence of an ideal equilibrium state where the marginal cost of mobility equals its marginal benefit. An equilibrium state is in most cases an elusive target, owing to the intrinsic difficulties entailed in attaching a value of sorts to the incremental costs and benefits of mobility. The measurement method proposed by Hauknes and Ekeland (2002) is a promising avenue, albeit demanding in terms of micro-level panel data. Hauknes and Ekeland (2002) propose calculating an equilibrium state of in mobility versus out mobility by evaluating benefits and costs in terms of experience (gained or lost). They use the duration of tenure with an organisation as a proxy of such experience. However, their method is highly restrictive in its assumptions of constant mobility rates across time and space, the certainty and constancy of knowledge accumulation and of the re-applicability of knowledge obtained in its entirety.

**Econometric Modelling**

Modelling necessitates that choices about specific definitions, realms of mobility and operative modalities are made. It comes as no surprise then, that existing models exhibit a great deal of variance in the above choices depending on the definition selected, scope and research targets. Modelling attempts, particularly ones seeking causal links between triggers and effects of mobility (as opposed to stylised mechanisms) are found in non-HRST specific studies. Despite the fact that they do not take into account the effects of knowledge flows, such studies are still relevant to the present survey since the basic process of ‘change of state’ is essentially the same. Such generic mobility models view mobility as a stochastic process (Hall, 1972; MacDonald, 1988), determined partially by numerous economic variables and being especially conditioned by actor heterogeneity.

Where the level of detail in the data permits it and for sufficiently short spells of time, individual level choices can be modelled by discrete choice (also known as rational choice) methods. Such models are useful in explaining one-off events occurring in discrete time such as the transition from school to the workplace. These are two-stage models that begin with the derivation of the probability of mobility. This

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14 Arguably though, the explanatory factors identified by non-HRST empiricism may not always be of relevance; potential candidates for endogenous variables also need to be drawn from studies taking knowledge communication issues into consideration.

15 For a comprehensive survey of studies in the field see Ryan (2001).
probability is then made dependent on a number of explanatory factors. Thus a general specification of the probability function of mobility $p(M_i^t)$ would look like:

$$p(M_i^t) = \beta X_i^t + \varepsilon_i^t \quad (1)$$

In equation (1) the probability of an individual to change job in time $t$, is dependent on a set of factors $X$ and an error term $\varepsilon$, where $i$ refers to the realm across which mobility is occurring (i.e. firm, sector, region, country etc). $X$ may include the individual’s characteristics, his or her previous history, as well as sector, region or institution specific determinants. For example, Shaw’s (1987) model proposes inclusion of a measure of the value of staying with the organisation, a measure of the value of joining another organisation in addition to tenure time and firm, sector and individual characteristics. In another example, Hall (1972) employs a logit model in order to explain differences in the discrete frequencies of employment states, conditional on the characteristics and history of the individual as well as his or her surrounding environment. Hall (1972) thus illustrates causal relationships and their varying gravity, effectively producing a set of probabilities that a given change in an explanatory factor will lead to a predictable change in mobility.

Given the importance of the accumulation of tacit knowledge, there is special value in approaching HRST mobility from the angle of employment duration. Issues relating to the counting of duration (i.e. the ‘spell’ or in this case, the employment spell) and as well as the specification of associated models are outlined in Heckman and Singer (1986), Kiefer (1988) and Gouriéroux and Magnac (1997). Duration models are also two-stage models imposing a number of assumptions on the probability of a particular duration. To begin with, the spell’s start- and end-point in time is required for each individual. Limitations imposed by the nature of surveying mean that data are bound to be censored, i.e. surveys performed at time $t$ will only capture accurately the employment duration of those individuals who had changed job by time $t$, as for the rest the duration of employment will extend beyond the interval covered by the survey. Additionally, the inability of many surveys to record multiple changes of state within the survey’s time-span means that short spells are not recorded, a problem referred to as length-biased sampling (Kiefer, 1988). The probability distribution of spell duration $T$ is a random variable, corresponding to a cumulative distribution function:

$$F(t) = Pr(T < t) \quad (2)$$

Since the data is censored, the probability that an employment spell lasts at least time $t$ is given by the survivor function:

$$S(t) = 1 - F(t) \quad (3)$$

Conversely, the probability that a spell ends in time $t$ is given by the failure function:

$$f(t) = dF(t) / dt \quad (4)$$

Campos and Dabušinskas (2003) present an extension of the model using a ‘skills transferability index’, which they found to affect mobility positively.
Hence the probability of an employment spell of duration $T$ lasting until time $t$, (conditional on it not having being terminated by time $t$) is given by the ratio of functions (4) and (3), i.e. the hazard function;

$$\lambda(t) = \frac{f(t)}{S(t)} \quad (5)$$

Using (5) one can proceed to specify functional forms for the economic parameters and decide on the hazard’s dependence on observed and unobserved variables. Both the form of the functions as well as the list of the regressors is a judicious matter; it depends on the context of the study, underlying economic theory as well as the significance of any unobserved variables. Since duration occurs in continuous time, once a specification has been arrived at, the same functional form can be used to explain events occurring in different time intervals (Heckman and Singer, 1986). Various specifications allow for modelling the hazard rate against time-invariant variables (at least for the period of analysis) such as the individual's characteristics. The effects of time-varying determinants can also be captured by way of inclusion of dummy variables for a particular time unit (e.g. quarter or year). Sorm and Terrell (2000) performed an application of duration analysis using labour force survey data for the Czech Republic. They found that an individual’s demographic characteristics, job characteristics and localised quarterly demand conditions all affected labour mobility. Other examples of duration modelling link mobility to sectoral shifts (Lucas and Prescott, 1974) and labour demand and supply mismatches (Jovanovic and Moffitt, 1990).

4. HRST Data for Ireland

In Ireland two primary sources of data readily lend themselves to the measurement of HRST stocks; the ‘Quarterly National Household Survey’ (QNHS, or ‘Labour Force Survey’ for pre-1997 data) and the Census (CSO, 2002), both compiled by the Central Statistics Office (CSO). Although not explored here, a limited amount of complementary information on the supply of HRST could be obtained from records kept by the College Admissions Organisation (CAO, 2005), the Higher Education Authority (HEA), the Institutes of Technology, further education colleges and the various employment associations for scientists and engineers. Among the sources of data that may present opportunities for measuring and explaining HRST flows are the QNHS, the ‘European Community Household Panel’ (ECHP) survey as well as the ‘First Destination of Award Recipients’ survey (HEA, 2004).

The QNHS forms part of the European Labour Force Survey and is now the quarterly implementation of what used to be (until April 1997) the annual ‘Labour Force Survey’. The QNHS produces data on the numbers of those unemployed as well as those in employment. It collects individual data for 39,000 households per quarter,

17 For treatments of unobserved variables see Blossfeld and Hamerle (1990) and Jacoby and Sharma (1992).
18 Membership information from such organisations as the Institution of Engineers of Ireland, the Environmental Sciences Association of Ireland, the Biomedical and the Clinical Engineering Association of Ireland may yield useful insights.
allowing for breakdowns by region (NUTS\textsuperscript{19}), industrial sector (NACE), education and demographics. Of interest to a stock-counting exercise would be the information collected on educational qualifications (subject, level) as well as occupation. From 2003 onwards, the QNHS asked questions on both the field of third-level qualifications (variable \textit{edufield}) and crucially the year in which individuals started working in a firm (variable \textit{yrstart}), allowing the partial measurement of an employment spell. The QNHS also registers other interesting data, including levels of qualification\textsuperscript{20} and the number of work-hours. Unfortunately though, the QNHS does not record information on the employment status of participants in the previous year, thus prohibiting the study of immobility\textsuperscript{21}.

The CSO possesses Census data dating back almost a century (with the earliest intact dataset being that of the 1911 Census), but as one would expect, there is great variation on the questions asked over the years. Special care need be taken as there are definitional and concordance issues both across Census datasets and with regards to their contemporary ISCO and ISCED conventions. The Census collects data on individuals such as educational qualifications (subject and level of study), occupation (industry and profession) on top of a rich set of demographic characteristics.

The Irish part of the ECHP survey is known as ‘Living in Ireland’. It surveys the same individuals over time and is a prospectively excellent source for the measurement of stocks and flows. Due to the logistics involved in a longitudinal survey, the dataset suffers from a relatively small sample (typically less than 5,000 households) and attrition (Watson, 2004). The ECHP provides a broad set of data on employment (variable codes \textit{PE001-PE0039}), including ISCO occupation (variable \textit{PE0006}), month and year of start of employment (variables \textit{PE011-PE012}) as well as the month and year individuals left previous employment (variables \textit{PJ002-PJ003}) and the occupation in previous job (variable \textit{PJ007}) (Eurostat, 2001). In terms of education, the ECHP collects information on the highest level of education completed (variable \textit{PT022}) but, regrettably, not on the field of education (Eurostat, 2001).

In understanding the transition of HRST from tertiary education to employment, the Higher Education Authority’s annual “First Destination of Award Recipients in Higher Education” (HEA, 2004) survey provides valuable information. The survey attempts to establish the status (employment or further education) of third-level graduates a year after graduation and has been held annually every year after 1982. It contains information such as the graduates’ locality of origin, their place study, socioeconomic attributes as well as their employment destination broken down by industry and profession. The resulting rich dataset can form the basis for an in-depth explanatory analysis of the occupational outcomes of S&T graduates.

\textsuperscript{19} Eurostat’s Nomenclature of Territorial Units
\textsuperscript{20} primary, secondary, third non-degree, third degree & above, but no ‘fourth’ i.e. PhDs and Postdocs
\textsuperscript{21} In fact the QNHS is the only survey among its European Labour Force Survey counterparts, which does not record this information (OECD, 2001).
5. Conclusion

Comprehensive statistics in the stocks of HRST and their flows can play a vital role in informing all major pillars of public policy. Policy makers in Ireland have an active interest in information pertaining to the supply of labour, as demonstrated by the formation of the Expert Group on Future Skills Needs within Forfás. In terms of innovation measurement, HRST statistics can complement traditional R&D statistics, especially for the non-manufacturing sectors and for small and medium sized firms (Nås, 1998). While there is a more or less clear picture of current HRST stocks (EGFSN, 2004), a broad view of mobility tendencies is still lacking.

The measurement of mobility rates and breakdowns by region, field and level of education could indicate the effectiveness of particular regional and educational policy schemes. Existing modelling approaches are receptive of adjustments which assume knowledge endogenous. A modelling exercise could highlight knowledge costs and gains by region and sector. Hall (1972) demonstrated that given the right conditions, there might be an inverse correlation between the rate of labour mobility and the overall level of employment. In the case of Ireland, information with regards to mobility could be of greater importance today than a decade earlier; the discrete choices of individuals may indeed matter more in a state of full employment. This provides fertile ground for formal modelling approaches, seeking to explain decisions to enter or exit employment as well as factors influencing its duration.
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