

The Modern Census: Evolution, Examples and Evaluation

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Abstract

A national census provides important information on a country's population that is used in government planning and to underpin the national statistical system. Therefore, the quality of such information is paramount but is not as simple as the crude accuracy of population totals. Furthermore, changes in the pace and nature of modern life, such as the growing geographical mobility of the population, increasingly pose challenges to census practice and data quality. More recently, even the need for a census has been questioned on grounds of financial austerity and widespread availability of alternative population information sources. This article reviews how the modern census originated and how it evolved to confront these challenges, driven by indicators of quality and needs of users, and provides reflections on the future of the census within the national statistical infrastructure. To illustrate our discussions, we use case studies from a diverse range of national contexts. We demonstrate the implications that a country's needs, circumstances and experiences have on the census approach and practice while identifying the fundamental demographic assumptions.

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1. Introduction

The aim of a census is to provide relevant population data to users in context, but it follows that this data must meet users' expectations in terms of quality, appropriately defined. Hence the assessment (and evaluation) of quality in a census is important, primarily in fostering confidence in the data produced by the census but also for planning for future data collection. Further, the management of quality in a census is vital because the census serves as the benchmark for the national statistical system. Population data are projected forward from census day and are used to underpin surveys, for instance in drawing samples and making statistics representative of the whole population. Therefore, the census acts as the baseline for comparison when users go on to collect their own data. The census is also the best, if not the only, source of information on small population groups in terms of area or membership. Additionally, the census is a pivotal part of the official statistics produced by a country because it, typically, provides the benchmark for the population count at national and local levels. Finally, a country's census information is used by international organisations in projections of the world population, and relatedly, it underpins national accounts which allow the understanding of international credit risk. The census has a unique role in both the national and international statistical system.

A census is often assumed to be an elementary exercise, eliciting the same information from everyone, with the serious issues being the cost and the choice of questions (Kertzer and Arel 2002). However, a census also needs a list from which to select people to gather information. To begin with we must define what is meant by a census, more precisely than to say it is a sample survey in which the sampling fraction is 1. While a range of definitions exist, this paper will use the United Nations definition (UNECE 2006, pp. 6-7). Here a census is defined as an operation which produces an official count of a country's population, right down to the lowest level of geographical detail, at regular intervals. This definition states the essential characteristics which differentiate a census from other exercises: individual enumeration, simultaneity, universality and defined periodicity. Hence a census obtains information on everyone, at the same time, from the whole country, and is repeated on a regular basis. This definition disguises a wide variation in approach, context and quality of outcome. By reviewing these, we aim to show that there are common themes in quality which apply to the modern census, even as more variation develops in practice.

The modern census is considered to have emerged in the period after the 18th century, when it is widely accepted that nations started conducting censuses in line with established statistical methodologies and, later on, internationally agreed definitions and recommendations. We will attempt to differentiate this 'modern' census from the historical censuses of the Romans, Greeks, Egyptians and Chinese, which served a different purpose. Missiakoulis (2010) asserts that the first true census took place in the 16th century BC in ancient Athens; earlier surveys had included only men with the specific aim of evaluating military potential. Historically, these censuses developed from the idea of a numbering, or enumeration, using processes as simple as counting a pile of rocks where each individual added one to the pile (Missiakoulis 2010). The focus of these censuses were primarily on military capability or tax collection, and mainly used by the political administrators (Rusnock 1997).

In the eighteenth century, the premise that

“the true measure of the power of a state is in its population” (Hacking 1990, p.18)

led to central statistical offices being established to produce statistics of the population in Western countries. Thus, the first censuses were implemented well before the advent of sampling theory, meaning that counting the whole population was the only reliable method of getting any demographic statistics (Bethlehem 2009). However, methods of census taking were not confined to universal enumeration even then, with Montyon and Laplace in France identifying the possibility of using demographic regularities, such as the birth rate, combined with administrative sources - in this instance, a register of births and deaths - to make indirect population estimates (Rusnock 1997). Later this progressed to a more familiar approach which identified households as the primary units where individual enumeration would take place and the recording of attributes such as age and sex became as important as counting the individuals. This allowed comprehensive, coherent and simultaneous enumeration to be made rather than the aggregation of numerous idiosyncratic local records (Higgs 2003). Census enumeration spread from European nations to their colonies around the world (Hooker 1894), and they also developed independently in some American nations.

In this paper, we hope to provide an accessible account of the nature of the modern census, as well as the current pressures and compromises that affect its further development. As mentioned, the historical practice focused on administration and taxation, rather than understanding the local population. We focus on the modern practice, and consider how this has developed the quality of demographic statistics. First we define what we mean by quality for a census, and highlight the important role the census plays in the understanding of a nation, taking into account the diversity of the international context. We then elaborate on the development of the ‘traditional model’ of census and how various countries have diverged from this to allow for their national context by looking at different case studies. The fourth section discusses the evolution of census utility, the importance of census data in modern governance, and presents considerations for the changing use of census data. The fifth section offers considerations on how to evaluate census quality and draws attention to specific issues pertaining to the case studies discussed in earlier sections. Finally we discuss future challenges for the modern census model caused by changes in data needs and availability, and the implications this has on census quality. We conclude with some remarks on international priorities about improving census quality and the nature of the contemporary census.

There have been many learned arguments proposed as to the technical approaches to an estimation of census counts and their practical limitations, such as the challenges posed by dual system estimation (Breiman 1994; Redfern 2004; National Research Council 2009). We do not go into these here for three reasons: a) there has been much give and take on these technical aspects, and the intention of this paper is to reach a more general audience; b) they are often country specific in that cultural norms and constitutional requirements play an important role in the practicalities of data collection; and c) they focus only on one aspect of quality, absolute accuracy, whereas we identify several competing aspects.

2. Understanding Census Quality

The overarching purpose of a census is to obtain and produce data and, from this, generate information beyond what is already available. Therefore, assessing census quality translates to an assessment of the quality of information produced, however defining quality is difficult. Historically, quality would have been synonymous with accuracy, as data were simple, use was restricted to government and there were no other national sources of population information. Quality could be construed as the usefulness of information, but there is a diversification of users, especially with regards to the information produced by the census. Alternatively, quality could be related directly to the value, but this risks confusion where census counts are derived from registers and their marginal value is difficult to specify. While a combination of value and utility could be used to examine the quality of information, this is not the intention of this work. Instead we assume that quality represents the informational potential of the data released, encompassing the significance of users and how the new data has utility beyond existing sources, that is, everything which can be controlled by the national statistical office (NSO).

Lynn (2003) identifies differing approaches to survey quality from an international perspective, prioritising national utility or international comparability. With the stakes of national governments in the census being so high, the former approach has historically dominated (see Section 4). The quality of data is related to its utility and the most widely used definition of quality relates to its 'fitness for use' (Herzog et al. 2007, p.7; Brackstone 1999). The 'fitness' subtly accepts our contention that while acknowledging that data itself has no quality it only has potential value when it is used for a purpose. Thus, within a census context, quality is a multi-dimensional construct describing the nature of the information, being characterised in terms of six elements, namely: relevance, accuracy, timeliness, accessibility, interpretability and coherence.

- a) The *relevance* of information reflects the degree to which census data is designed to meet the needs of the population, users and stakeholders. This, therefore, places limits on what can be collected and is rooted in the national context.
- b) The *accuracy* of census results is the degree to which the data describes the phenomena of interest. This primarily concerns the reliability and precision of the data.
- c) The *accessibility* of census data refers to the availability and ease with which the data can be obtained by the stakeholders and public at large. This is driven by issues surrounding ownership and confidentiality of the data.
- d) The *interpretability* refers to the degree to which the information is easy to understand, such that any salient census results and supplementary information are easily determined by a prospective user. In essence this dimension of data quality focuses on how the information 'makes sense' to users.
- e) The *coherence* of census information reflects the degree to which the census data can be brought together with other existing, or user generated, statistical information and within a broad analytic framework. Thus it encompasses both internal consistency and external comparability.
- f) The *timeliness* dimension refers to the time frame of the (periodic) census process. This is related to the relevance dimension, since some data may be more time pressured than others, and this may vary for different users.

These elements, although suitably distinct, are interrelated and may be conflicting, with actions to improve one dimension impacting negatively on others. Consequently, any assessment of quality needs to examine all of these rather than just one in order to gain a realistic understanding of the quality of a census. However, this does not mean that there is only one optimum balance to be obtained in terms of quality, even for countries with similar budget and quality expectations. Indeed countries are experimenting more than ever with different census operations that require a careful appraisal against a comprehensive quality scheme to understand their strengths and weaknesses. Moreover, different users may be prepared to compromise on certain aspects of quality in order to improve others, indeed timeliness is more important than perfect accuracy to some business users (Judson 2007). We return to the role of users in the census process after first considering more general features of the development of the modern census.

3. The Development of Census Practice

A census represents an incredibly detailed snapshot of the population of a country and, being repeated typically every ten years, it builds up a picture of national evolution. This picture comprises not just the data itself but also the questions that were asked and how the data were collected – all of the metadata (information about what the data means) and paradata (information about the data collection process) are key aspects of the census. In the majority of countries, particularly those with a long history of census taking, such data forms the backbone for understanding demographic and social trends within the country. Further, the information is increasingly compared with that available in other countries, showing not only different demographic composition but also diverse census strategies and questions. It is important to note that while there is a process of continuous quality improvement between censuses, this process is influenced by cultural situation and national development and so takes different forms in different countries.

We now review the evolution of modern census practice starting with the “traditional model”, which we define only through examples, followed by deviations from the standard model. Furthermore, as practice is contingent on country circumstances and some census models have been partially implemented in some countries we focus on countries with stable implementation. This allows us to highlight how specific changes have altered the quality profile of census enumerations to reflect on the compromises made between the different dimensions on quality, as outlined in Section 2.

The traditional census: The UK and Malaysian case

The traditional model of census can be exemplified by the UK experience. In 1798, Thomas Malthus wrote an influential treatise ‘Principle of Population’ in which he argued that population growth would supersede agricultural production leading to starvation and famine. Although records of births and deaths were held in every parish, there was no centralisation of statistics or consistency in the way data were recorded. In particular migration from place of birth was not recorded (Higgs 2003). Based on Malthus’ predictions, Parliament passed the Census Act in 1800, with the view of gaining an accurate count of the current population. The first official census took place on 10th March 1801 and revealed that Great Britain’s

population at the time was approximately 10 million living in about 2 million households. With the creation of the General Register Office in 1837 (Mahon 2009), the census of 1841 was widely regarded as the first truly modern census. A field force of professional enumerators was employed to undertake the count of the population. Information was collected on all individuals present in the household on the specified census day.

Prior to this census information was collected by leaders of the individual parish communities, who merely gave a head count of the population and recorded very little personal information about people other than the head of household. The format used in 1841 still forms the basis of census data collection in use in the UK today, though with substantial changes in the questions asked, for example the addition of questions on housing in 1951. The influence of British census-taking spread across the empire, although it was not until 1920 that the UK passed a permanent census act despite a perceived need decades earlier (Hooker 1894). Original census returns are made available to the public through national archives through a rolling programme of release, ensuring that census data is kept confidential for 100 years, a practice replicated by some other countries, albeit with variations on the time to release.

Censuses have been carried out in the UK every decade since, apart from the 1960s when there were two censuses held - in 1961 and 1966. In April 1966, an alternative method of enumeration using a long form/short form format was trialled (similar to the US case, considered next). There was no census held in 1941 due to the Second World War, however there was a smaller-scale census count held in September 1939 to enable National Identity Cards to be issued to all people in the lead-up to the war. Over time, a shift was made to enumerate the population at their usual or 'de jure' residence, rather than where they happened to be, or their 'de facto' residence. This is much more relevant in the allocation of funds which is needed to determine where people access services such as schools and hospitals, but it makes it much harder to evaluate an accurate count if people are away on holiday for long periods. This 'de jure' approach is also much more natural in its interpretation. However to maintain a coherent count, it requires a very clear definition of 'usual residence' which can be particularly problematic for students or other population groups characterised by multiple residence or high mobility.

The most recent UK census was held in March 2011, and involved posting around 30 million questionnaires to all households using a complete national address register. Census is a devolved matter in Northern Ireland and Scotland with independent but comparable operations taking place; in Wales the same operation was followed with the inclusion of a full Welsh language option, and an additional question on Welsh language speaking. A quality survey has followed censuses for several decades to identify item response accuracy. However, since 1991 there has been a post-enumeration survey to provide robust census population estimates and assess quality (Abbott 2009).

The traditional model has generally been adopted by countries where the census has a relatively young history, including most developing countries. An example of this is the South East Asian country of Malaysia which was formed in 1963 as a federation of former British protectorates and the independent country of Malaya. Colonial administrators established census data collection early in the 20th century but these were for management and used colonial categories and are of limited comparability to the modern mapping of the population (Christopher 2005; Kertzer and Arel 2002). Censuses have been held in 1970, 1980, 1991, and 2000. The fifth and most recent census was held in July and August 2010,

and was the second to enumerate individuals on a de jure basis rather than a de facto basis. Due to Malaysia's diverse population the current census has adopted an innovative multi-modal design where face-to-face interviews are conducted in rural areas while the large, highly skilled urban population had access to self-enumeration. Further, the census questionnaire could also be securely completed electronically, to allow for the preferences or lifestyles of the mobile population (Department of Statistics Malaysia, 2010). It remains to be seen how this approach will affect the coherence of the data due to the possibility of modality bias but it is expected to increase the accuracy since it increases the response rate and the completeness of responses.

Traditional census with yearly updates: The US case

It has widely been argued that the long span between consecutive censuses has a detrimental effect on the usability of census data, especially at local geographical levels where changes may be rapid. To address this, some countries employ a variation on the traditional census design, combining traditional enumeration with yearly updates. Here regular household surveys are used to obtain detailed characteristics of the population on a frequent basis. However, the basic demographic characteristics of the population are still collected every decade or so, with the dual purpose of benchmarking the census estimates and providing coverage improvement. The US case exemplifies this approach.

The first official US census was carried out in 1790. This was mandated through an article in the 1787 Constitution, which called for the creation of a periodic census to measure the population in different parts of the nation. The census act is explicitly the basis used to apportion representation in the legislature, making the US census unique (Anderson 1988, p. 9). Since 1910 census data has been collected every ten years by the US Census Bureau which has responsibility for undertaking the data collection. Prior to this, responsibility for census data collection was assigned to district marshalls appointed by the federal government who reported directly to the President (US Census Bureau 2010).

From the 1940 census until the 2000 census, a separate household 'long form' was used to collect extensive attribute information, such as education, employment and housing, from a selected sample of households while every household received the 'short form' collecting basic demographic information. Since 1960 the US Census Bureau has mailed out questionnaires to households rather than using enumerators. The introduction in 2010 of the American Community Survey, which collects information on an ongoing basis from 250,000 addresses every month (roughly 3 million per year), has led to the long form being discontinued (Pierce 2008). Thus the census has primacy for constitutional and benchmarking roles, but more timely and detailed data is available to users albeit subject to sampling error. In contrast to the UK, original census data are kept confidential for 72 years and are made available for research thereafter at the National Archives and libraries in various parts of the country (US Census Bureau 2010).

The rolling census: The French case

To answer the increasing demand for data that is up-to-date and regular, some countries have considered using a rotating (or rolling) census. This was originally proposed in the 1970s by Kish (1979) as an alternative to the traditional model, providing more current and timely census data, in addition to spreading the costs and burden of conducting a census evenly over the census cycle. Thus, a continuous survey covering the whole country is undertaken, over a period of time. Instead of enumerating the entire population at a single point in time, the population is subdivided and a full enumeration of one section takes place, and followed by the next, and so forth. The data is not as current as a traditional enumeration, but benchmarking is still possible with detailed data.

The rolling census is exemplified by French censuses since 2004. The French rolling census delivers detailed population data on an annual basis for the 36,862 local administrative units, referred to as communes. This is done through an annual survey specifically designed to cover approximately one seventh of the population in a year with a five year rolling cycle. Communes are treated differently according to their population size so that small rural communes are completely enumerated every five years in the traditional manner but larger communes (mostly located in urban areas) are enumerated through annual surveys. The change of census methodology was enacted in the national census law in 2002 (Clanché 2011). The definition of the relevant population becomes problematic since not everyone in the country is counted at the same time. However, there have been careful design measures put in place to help ensure that the lack of simultaneity of the population figures is counterweighed by the relatively high frequency of the census data (Cézard and Lefebvre 2008).

The register-based census: The Swedish case

Administrative registers have been proposed as an alternative for providing census information, especially as administrative data becomes ubiquitous in official statistics. Most countries collect detailed demographic information from their population on births and deaths, and a large number of countries have administrative registries on employment, education and residence, that can be harmonised for censuses purposes. The Nordic countries (Denmark, Finland, Norway and Sweden) have had a long tradition of collecting data through administrative registers, and using these for the production of official statistics. We highlight the case of Sweden, which converted from using a traditional census to an indexed population register-based census. The Swedish experience, which is similar the other Nordic countries, shows that there is often not a direct shift from traditional censuses to a fully-register-based census, but a gradual movement over time.

Early Swedish censuses collected information from the public through questionnaires, following the traditional model. The beginning of the change towards a fully register-based census can be traced to 1967 when the central population register was established. This was an administrative register of all vital events (births, deaths and marriages). What made this innovative was the inclusion of a unique personal identity number (*personnummer* in Swedish) which allows individual's information to be linked and updated through time. Thus, from the 1970 census there has been an increasing use of information from the administrative registers for census purposes. Legislation was drawn up that reflected the broadly held view that it made good sense to take advantage of the existing administrative

data sources rather than recollect data from the general public. An act of parliament gives the national statistical institute the right to access administrative data on a unit level with identification data and to link them with other administrative records for statistical purposes (UNECE 2007, p. 7). The 2011 census was entirely administrative-based, that collected no data collection from the population but utilised a number of different registers linking housing and population records to produce census information.

A major issue in register-based censuses is producing household statistics, with the definition of household varying from dwelling and this information not being collected by administrative registers. Therefore, the statistical offices of the Nordic countries have developed a framework for evaluating the statistical accuracy of information produced by register-based censuses (Zhang 2011). It is also true that traditional censuses face the challenge of getting population and household statistics to be coherent. This is especially true when people are recorded in the census with imprecise addresses, and statistical procedures have been developed to ensure that the final data are adjusted so that there is agreement between the population and household characteristics (Isaki et al. 2000; Brown et al. 1999).

The ‘virtual’ census: The Dutch case

With the wide availability of well-designed, nationally representative annual surveys, some countries are obtaining their census information by compiling data from different administrative registers and sample surveys. This is because, it has become increasingly evident that regardless of whether or not data is simultaneously collected during the census on a wide range of topics, the swiftness of changes in the population characteristics make annual survey data important in official statistics. Further, the requirement for additional detailed data on demographic, social, economic and housing statistics which are not appropriate for collection in a full scale census has motivated the need for a continued programme of annual, relatively regular, sample surveys. One such country that has moved from the traditional census model to this approach is the Netherlands. While supplementing regular enumeration with frequent surveys is similar to the US case, the difference, as discussed further below, is that the regular enumeration of the population is accomplished through administrative registers. There are also similarities with the Swedish case, but the differentiating feature is that the Dutch case uses sample surveys to complement the areas that lack comprehensive administrative data.

Like most European countries, the Netherlands has had a long history collecting censuses. However, the 1971 census became the last traditional enumeration with the census planned for 1981 postponed due to privacy concerns and then cancelled. In 1991 a census was again planned but cancelled as a result of the protests about privacy and the general public’s unwillingness to participate. Following this, census legislation was changed, and the law stating that a census should be held every ten years was repealed. In response, Statistics Netherlands found an alternative way of collecting population information by consolidating the records of other administrative and statistical operations. The approach uses a combination of available registers and social and administrative surveys to create a social statistics database to produce ‘coherent’ and detailed demographic and socio-economic information about persons and households. It has allowed the Netherlands to produce census data with timeliness to suit the users using comprehensive administrative records, complemented by social surveys with low undercoverage to provide additional attribute data.

In 2001 and 2011 the Netherlands used this approach to produce a ‘virtual census’, where rather than enumerating the entire population, the census was simulated by merging data from existing surveys and administrative registers. The census simulation was done through a statistical estimation method referred to as repeated weighting (see Renssen and Nieuwenbroek 1997). Repeated weighting ensures that the records in the microdata (information from the individual files), produced by combining register and survey information, are consistent with the earlier data sources. In this way, coherence and accuracy are treated as the same problem, and has the benefit of eliminating the problem of inconsistencies between different data sources. Additionally, eliminating the need for fieldwork means that estimates are much timelier than the traditional approach. An obvious concern of the ‘virtual’ census is its reliance on high quality surveys, in addition to a variety of administrative sources the NSO is able to amalgamate. Also, the approach requires adjustments to reflect changes in available surveys and registers each time a census is produced; it is not the case of replicating the process from the previous iteration (Statistics Netherlands 2012a). Throughout the whole process, there is a detailed quality framework to systematically assess the quality of the data (Statistics Netherlands 2012b).

The legal basis of the Dutch ‘virtual census’ is underpinned by 2003 Statistics Netherlands Act, which replaced the rescinded 1991 Census Act. This is an important piece of legislation as it allowed for the combination of data from various sources for statistical purposes. As such, information about the population contained on registers, administrative lists and household surveys can be linked to produce a comprehensive database with individual information about geography, demography, income, labour, health and education. Key to the production of this integrated system is defined access by the NSO to all the existing registers for the purposes of statistical analysis. Within this access, a great deal of care has been taken to guarantee confidentiality of individuals. In addition, informed consent is sought from individual citizens, and people are made aware that the information provided in specific surveys and contained on the administrative registers is merged together for statistical purposes. This understanding, that information is matched solely for statistical purposes, is similar to the confidentiality understating in traditional censuses, whereby data collected is only used for statistical purposes.

4. Evolution of Census Utility

The basic idea of a census is to record every member of the population and aggregate these records into population statistics for the purpose of governance and private and public planning. However, this leads to the model of census typical of the early twentieth century. Recording requires individual responses, typically using a questionnaire completed by the respondent. With time, the census has become a familiar concept in countries around the world, and the concern shifted from taxation and governance towards social aspects: health and poverty could not be monitored without collecting some data from the whole nation (Kertzer and Arel 2002). This development is tacitly acknowledged in official discussion of ‘population and housing’ censuses, reflecting an interest in population structure and social units in our culture. This has meant that the census has had to constantly evolve to provide the required attribute data in relation to health, employment, education, transport, migration and other areas. Federal and central funds are often distributed to sub-national regions to provide particular services on the basis of population data from the census.

Needs for census data have developed partly reflecting the interest and the capacity of diverse users, beyond government, to make use of population survey data, and the greater development of social science and welfare policy. In dealing with large data even for a small area, computation has had a radical impact on the nature of dissemination (Uprichard et al. 2008). This has allowed data storage to be possible, first in universities, local government and large corporations, and now to individuals and small businesses. Also software for analysis is widely available, as well as analytics that are supplied by third parties.

Direct uses of census data include local service planning by regional government, and marketing and expansion planning by business. Academic researchers make extensive use of census through release of microdata (see McCaa et al. 2011) either in standard licenses or specially requested tabulations. While Harper and Mayhew (2012) demonstrated that it was possible to replicate local census enumeration, and there are many other data sources available to academics, national coherence can only be found in census. For more unusual groups it is only possible to find a sample which is both sizeable and reliably representative by using census, for example for studying internal migration. While census will add value for larger users, for small businesses, voluntary organisations and ordinary citizens, the census is a pivotal source for detailed geodemographic information.

Census also has an international dimension both in terms of use and users: data is important for facilitating international comparisons, for example in monitoring and evaluating progress towards the Millennium Development Goals. Governments also make increasing use of international comparisons to assess standards of public service delivery. This is a relatively recent development in census terms, but means that aspects of international coherence, interpretability and accessibility are becoming important considerations in census improvement. There is an international imperative for data to be collected, reflected in guidelines and recommendations prepared by the UN (e.g. UNECE 2006, UNSD 2008) and the EU. Comparability is identified as a particular aspect of quality assessment in the EU, as outlined in point 5 of Annex II to Regulation (EU) No 1151/2010 which states:

“For each topic, Member States have to report on any definition or practice in the Member State which could impair the EU-wide comparability of the data.”

(Eurostat 2011, p. 35)

While international concordance of population enumeration and labour and demographic classification is becoming more important, there are still competing estimates of the global population, highlighted by disagreements about when the population reached 7 billion (Champkin 2011) which stem in part from the different definitions used across the world. UN guidelines are important for the comparability of topics which have different categories or characteristics around the world (US Census Bureau 2012). Examples such as education and housing require international cooperation to produce consistent data. In addition, languages vary substantially in their individual importance between countries (Christopher 2010) and ethnicity is fraught from an academic perspective of classification (Kertzer and Arel 2002). Initiatives from international organisations to improve quality and to understand comparability across cultures will become increasingly important as the assembly of population statistics becomes more of an international enterprise (McCaa et al. 2011), especially as individual countries are limited by constitutional restrictions on geodemographic classifications used. Census is in essence an international enterprise as other countries tend to be the only source of contemporary expertise available when there are

questions about improvement or development. Thus, international meetings play an important role in developing standards and sharing experience (US Census Bureau 2012). However, although most countries see the census as an essential component of effective government, some have not been able to undertake census operations without support from international bodies (Bradford-Smith 2012).

The challenging census: The Democratic Republic of Congo case

We have mentioned that there is often an international dimension to censuses, and census data is important for measuring international development priorities, and establishing better government through improved information and increased statistical capacity. Therefore, in countries that lack the capacity for carrying out census operations on their own, censuses are undertaken under the auspices of international organisations. We give an example of the major challenges to establishing a census in such a country without a history of census collection. The Democratic Republic of Congo (DRC), formerly Zaire between 1971 and 1997 and before then the Belgian Congo, until independence in 1960, is a very large Central African country roughly two-thirds the size of Western Europe. There was no population census conducted during colonial times, and in 1984 the first, and only, census was conducted.

Due to civil war and unrest, no further censuses have been undertaken. Plans for a census in July 2011 were postponed to 2012 and then delayed again. This census intends to use around 70,000 enumerators to visit every household in the country (Bradford-Smith 2012). Official estimates of the current population vary from 65 to 73 million (Ebulelang 2010; IMF 2011), reflecting the uncertainty around migration, mortality and fertility since the 1984 census. The impact of HIV-AIDS, a major driver of mortality in DRC, is especially strong in urban areas and its extent it is difficult to estimate. Wars, droughts and food shortages in sub-Saharan Africa have also caused considerable displacement and death, making it difficult to identify the population of individual countries. This does go to show the limitations of available data sources in areas where census operations are separated by periods of profound change. Further, accuracy and interpretability pose challenges in African countries where the household-based nature of standard census models does not make the same cultural sense (Randall et al. 2011), especially in the context of conflicts and displacement, leading to possible double counting. Current plans suggest there will not be a post enumeration survey as recommended by UNSD (2008) but instead comparison with administrative records and other processes will serve to validate the enumeration (Bradford-Smith 2012). The results of such a census will provide reliable statistical data, not only for economic and social planning but also for the post conflict reconstruction and development.

5. Evaluation of the Modern Census

Developments of the census are designed to improve the census quality in terms of the dimensions described in Section 2. These improvements often involve compromises, hence evaluating the quality of a census is not just a checklist of best practice but an evolving assessment based on the interdependence of these six dimensions. One example is the shift that most countries make from 'de facto' to 'de jure' residence: this makes people harder to

count and reduces accuracy, but counts people where they conduct their lives, increasing relevance. The Netherlands has much more timely estimates coming from its ‘virtual’ census activities but this sacrifices the relevance of collecting extensive attribute data in a traditional census (which they make up for in their social surveys). Technology is being introduced in terms of multimodality (as in the case of the UK and Malaysia) which has the potential to increase response rates and therefore accuracy but must be monitored to ensure that paper and electronic responses are equivalent and internally coherent, as well as ensuring appropriate levels of security. Censuses have developed over time, and it is clear that the experiences of previous censuses have played a great role in influencing how future censuses are run. Thus in the DRC it will be challenging to evaluate the accuracy of census counts; nevertheless the data collection will still be based on updating the mapping produced from the last census held in 1984.

The evaluation of a census needs to encompass what the exercise has added to the known information about the population of a country and the value this has to users.

Section 2 outlined the different dimensions that encapsulate this construction of quality. Baffour and Valente (2012) have previously considered how these dimensions can be assessed from the perspective of different census methodologies. However, as shown in Section 3 an essential component of census evaluation is the historic information about the country’s population. While the idea of a metric of census quality is appealing, it is difficult to devise such a metric that will reliably facilitate national comparison. This topic is becoming much more interesting because of the variation being introduced as countries experiment with new methodologies in response to political circumstances as well as aiming to enhance quality while reducing cost. Quality improvement now encompasses trade-offs between different dimensions as well as investment in future gains in efficiency and quality.

The census can be the most complex peacetime exercise which a country undertakes (UNSD 2008), and the standard model of census taking which emerged in many countries in the form of a decennial ‘juggernaut’ means that census information has to meet the varying national needs as well as different priorities for quality and value for money. From an organisational point of view, the evaluation should allow verification of whether the very large effort and investment of resources demanded by the census are worthwhile, or whether data are available from other sources. From a measurement perspective, evaluation functions as a validation that the counts are always measured without error (although there must be a real value for the number of people under any population definition). Moreover, the complexity of conducting a census means that evaluation is useful for identifying aspects of census organisation that could be improved and contributing to the efficiency and effectiveness of future census operations (National Research Council 2009). Evaluation reports serve as a public commentary on the quality of census operations, highlighting flaws and operational development as well as engaging citizens with the geodemographic information. In the remainder of this section we discuss current issues of best practice; more detail can be found in Baffour and Valente (2012).

Best Practice Considerations

Relevance assessment is about prioritising informational gaps through research activities and consultation with users and stakeholders. Coverage errors can be measured using well-developed methods, such as post-enumeration surveys and demographic analysis, while content errors can be measured through piloting and assessing the quality of survey

responses. In addition, both managing content and coverage errors may benefit from international sharing of methodology. While timeliness was originally just a project management issue, it now encompasses the issue of data recency and periodicity. Accessibility is an external issue requiring extensive engagement but it also requires accordance for the ownership of data, confidentiality, archiving and eventual full disclosure. Interpretability is concerned with metadata, comparability and compliance but requires international cooperation for international standards. Internal coherence assessment is about assessing the quality procedures for dealing with accuracy such as imputation and disclosure control. External coherence checks can compare to other independent data, locally, nationally and internationally, as well as known demographic regularities. While researchers and large users may have the capacity to keep up with developments and engage proactively with NSOs, smaller users will need outreach and new products and services.

Census is the official count down to the lowest level of detail and it involves a diverse nation answering a small set of questions. Data is translated into information which has value through use and which is developing as user needs change and the national statistical context increases in complexity and integration. Census data often sits in the background as the denominator or the national benchmark, adding value to other data. Therefore, evaluation both validates the project of census and informs process improvement, and informs metadata that gives context to users. However, the quality dimensions can be also be useful from a planning perspective.

Many of these issues actually concern collaboration, consultation and cooperation as although census is a regular occurrence, it is infrequent enough for only limited knowledge to be retained in each country. These interactions make census a necessarily international enterprise since that is where the expertise resides as countries face the same developments in technology and similar developments in needs of users. Almost every country around the world is trying to conduct a census (US Census Bureau 2012) and those which suspended census have reintroduced the operation – a good example of this is the recent census in Afghanistan which was the first since 1979 (see Graham-Harrison 2013) . Nonetheless, the census landscape has been changing over the last two hundred years and will continue to develop as it is driven by the value of the information which it collects.

6. Future Directions for the Census

As the world's population continues to evolve, the priorities for census taking will change and the census will continue to develop. As outlined in Section 3, new statistical methods are being used that reflect the changes in the cultural and demographic landscape. Countries and international organisations continue to see a census as central in benchmarking national statistical systems. Nonetheless censuses continue to be national operations with national solutions and can be quite diverse. Despite its high cost, a census is still seen as a fundamental requirement as no other means of precisely estimating geodemographic attributes exists. However, many countries are looking to adapt their processes to improve quality and reduce costs (US Census Bureau 2012). This section elaborates some particular issues which are affecting contemporary census planning and how different countries are responding to them. Specifically we discuss developments in terms of technology and

procurement, privacy, methodological innovation, statistical registers, and demographic change.

A long time has passed since the first censuses were taken, relying on local administrators to produce official records for central aggregation. Planning, processing, piloting and evaluating extend the duration of a census programme way beyond census day and mean that censuses are considerable undertakings. For instance in response to a survey of NSOs, contracting of staff and operations was noted as being the biggest challenge facing the implementation of censuses (US Census Bureau 2012). The traditional form of the census has challenges in its capacity to procure contractors due to its enormous size (National Audit Office 2001) as well as recruiting and training temporary staff. Some countries use a municipal implementation making smaller regions responsible for local census operation, subject to centralised quality checks (ISTAT 2012). France has gone further, deploying a rolling census which allows the central statistical burden to be spread out, allowing expertise to be retained rather than lost in the churn between censuses.

The use of technology has presented some specific opportunities, some of which have only been implemented in a few of the most recent censuses. Others, such as digital technology for scanning, processing, storing and releasing data have already had an impact on the quality of information available to users. The use of postal services for questionnaire delivery is only fairly recent, due in part to the importance of ensuring universal coverage and enumerator follow-up on the ground. Thus the option for online completion in current censuses has been limited by the need for an access code to be sent to an address or issued by an enumerator on the doorstep (as in Malaysia). In Canada, high online response was achieved by sending an online code only as the first contact with no paper questionnaire (Statistics Canada 2012). Modality of response may well have effects on the internal coherence and completeness of data as internet access is related to socio-economics and the online version has more help available and requires answers to all questions. Unfortunately, evaluation of the impact of this is not yet possible.

Another use of technology in censuses is exemplified by the 2010 census in Brazil. This census illustrated the benefits of automating field data collection operations by using handheld devices equipped with global positioning software which enabled locations of households to be georeferenced directly. With Brazil's size, varying terrain challenges, language issues and small and remote indigenous populations, field automation was found to improve the census results (Bianchini 2011). A key benefit was the ability to achieve coverage of the population in a much more expedient manner, as the handheld devices were able to transfer data from the field to the national statistical census database in a fast and efficient manner.

To be valuable, censuses must collect sufficient information on each individual in a country, though this does raise privacy issues. Privacy is becoming more of a public concern as so much data become electronically linked to personal information and theft of such information makes people vulnerable. Legal frameworks for privacy are being developed to protect the citizens' human rights. The case of the European Convention on Human Rights is instructive where there is an exception to personal privacy where the use of information is of significant benefit and relevance to a wider community (Bingham 2010, pp. 75-76). The whole point of a census is that it helps a country to know itself and better understand its needs, so the requirement is simply that the census must make the case to the public of its importance and the reassure the security of the data it collects. Research in relation to privacy around the US

census elicited that respondents were more concerned about misuse of the data than personal privacy or intrusion, meaning that demonstrating the relevance of census to the population is essential in maintaining quality (Singer et al. 2003). While the quality of census is essential to their continuation, censuses around the world are also enshrined in statute and any changes must have legislative consent. Changes must also be supported politically as well as methodologically: any decisions to change the census must be taken after careful deliberation between politicians, academics, census officials and general public. The furore surrounding the Canadian government decision to replace the mandatory long form census with a voluntary survey is a case-in-point (see Yeo 2012 and Coleman 2013).

Almost every country that has had a census has started with the traditional model but many have changed their methods, particularly in parts of Europe, either to use other information, or to switch to a totally register based system (see Valente 2010). Using registers for a census is not nearly as simple as querying a database for the required population totals for two reasons: data is not in one source and administrative data does not normally meet statistical standards (UNECE 2007). Thus the creation of a statistical register is required, usually needing a legal basis and often combining data from various registers as well as surveys, in order to link individuals, residences and enterprises. The linking process has the benefit of improving the quality of registers; this feedback is typically tightly controlled. However, some countries, e.g. Slovenia (SORS 2012), have processes to allow the updating of registers in the census process. The degree of separation between statistical and administrative outcomes of the census is contentious because of privacy concerns and has meant strict constraints on access to the data as in the Netherlands. Assumptions must be made about coverage for an administrative census (e.g. that every person, dwelling, household and business is officially and correctly registered) making small homogeneous populations easier to enumerate but even so certain attributes may require surveying, such as the number of hours worked by the self-employed (UNECE 2007). However, the use of solely administrative data has only recently been achieved and processes to assure accuracy are still developing as coherence is excellent by construction but accuracy, in terms of both content and coverage, is difficult to assure (Zhang 2011). Administrative censuses hint at the future of the census in having the role of information integration and benchmarking (Eurostat 2012).

Most statistical activity responds to socio-economic activity which changes rapidly, even faster than the development of technology. Censuses typically take place over ten year periods which may be suitable for the benchmarking of statistical systems, but will invariably incorporate considerable political change. As we discussed in Section 3, some of these changes, from independence of former colonies to devolution in the UK, mean that the data considered relevant have changed. Furthermore, demographic data relies on households as sampling units but in some cases these are rather contrived entities defined by a particular shared resource (Randall et al. 2011). Moreover, with alternatives to households based around married couples, and individuals residing in more than one household (UNECE 2012), more relevant statistics have to be produced to meet these needs. It is often overlooked that census-taking actually requires sampling, albeit selecting every unit from the sampling frame, but the choice of sampling units, typically households, may be difficult to clearly define. Uprichard (2013) notes that the process of identifying what to sample is generally an iterative and reflexive process but it is inhibited in the census due to differences in living arrangements (UNECE 2012). These changes in living arrangements, including persons living internationally for employment or other reasons, affects not only the relevance of

census but also the capacity of national governments to undertake census without substantial international cooperation (de Beer et al. 2010).

The future of census is based on the future of the data it provides and how this adds value to the life of a nation. It is inevitable that the census has to evolve to ensure it properly measures the changes in a country's population, in terms of its composition and characteristics. This is admittedly becoming more difficult when there is the continued need for population statistics that are quick, accurate and, in these times of financial austerity, cheap. The census therefore has to adapt; one potential way is to efficiently use administrative and existing data to provide the required information more frequently and at a higher quality. There are considerable strides being made in this direction.

7. Conclusions

There are several different approaches to censuses and they must be appropriate to the context of the country where they are taking place. However, there are several issues to note. A census is not just a simple count, and often involves complex stratification as well as the use of more than one data source. Therefore, a technical specification of the methodology and its supporting assumptions is an essential part of planning a census. Developing a successful census strategy takes a long time: not only do countries plan a census for as long as a decade, they build up experience and capacity at the NSO over a longer period. A transition to a new methodology takes a long time and includes incorporating new requirements. This must be done while ensuring that the census builds on the quality and the estimates of previous estimates rather than being an isolated, independent enumeration. This is a challenge. In this context, countries may benefit from guidelines and recommendations developed at the international level (US Census Bureau 2012; ONS 2012). Any changes to the census have to consider the quality implications and indeed recent threats to census activities or possible reductions in the quality of census operations have prompted outspoken calls to protect census quality (Fienberg and Prewitt 2010).

Modern censuses are no longer the sole source of population information and are often supplemented, and to some extent supplanted, by sample surveys and administrative data. While modern censuses form the foundation of the national statistical system benchmarking the population to calibrate demographic statistics, and provide a basis for stratification of sample surveys, their importance may be concealed. The international dimension is becoming more important for cooperation and comparability and integration of data with other sources means that absolute accuracy is less paramount in importance. Though census is only one method of data collection and is not suitable to characterize every aspect of a population, in conjunction with other official data, a census can provide new insights into the life of a nation.

The future of the census in its traditional form is far from certain, but the need for population statistics and independent enumeration to validate other data is undisputed. The statistics required from census and the methods used to compile them are evolving more rapidly than ever. The changes can be very controversial and are seen by some to reduce quality, however they represent a compromise between accuracy and other quality dimensions which serve to better meet user needs. The notion of the census as the experience of households returning data is an anachronism, as exemplified in the case studies. Therefore, it appears to be more

sensible to consider the census as the whole process of benchmarking population statistics which apply to a defined population, are produced with a defined periodicity, provide universal individual enumeration and are accessible at the lowest level of geographical detail. Although desirable, simultaneity of enumeration is not necessarily obtainable when residence definitions vary, and administrative records may not record change of residence precisely. Thus census is a statistical estimate of population, appreciating that although there is a real number of people with any given attribute resident in a geographical area at any given time, uncertainties mean that this number cannot be determined with absolute precision. As Breiman (1994) says, the essential requirement with different approaches is that they should be evaluated for their quality, and this evaluation should be clearly reported alongside the census results.

Census began for purposes of national administration and it generally retains that role today as the basis for legislative representation, federal funding formulas and other statutory purposes. Additionally, it has a compliance imperative enshrined in statute which makes it inherently national in coverage and also political in nature as it could be construed to intrude into the circumstances of individuals. Indeed few questions in census statistics are without controversy as groups vie for inclusion of their unique circumstances, and as some issues are deemed too personal for compulsory response, others are too subjective. Hence, the census serves as the basis of objective statistics in contemporary democracies and will continue to evolve as technology and society present new data requirements. All census programmes are the result of compromise and systematic enumeration processes which require careful evaluation and consideration of context: statistics are not absolute truth but useful information. However, no matter what the circumstances of a census, all the international efforts have something in common: they remain the indispensable benchmark of the national statistical system.

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References

- Abbott, O. (2009). 2011 UK Census Coverage Assessment and Adjustment Methodology. *Population Trends*, 137, 25-32.
- Anderson, M. (1988). *The American Census: A social history*. Yale University Press: New Haven
- Baffour, B. and Valente, P. (2012). Measuring census quality, *Statistical Journal of the International Association for Official Statistics*, 28, 121-135.
- Bethlehem, J. (2009). The rise of survey sampling. Discussion Paper 0915. Statistics Netherlands. The Hague/Heerlen, The Netherlands.
- Bianchini, Z. (2011). The 2010 Brazilian Population Census: innovations and impacts in data collection. Paper Presented at the 58th World Congress of the International Statistical Institute (ISI), 21-26 August, Dublin, Ireland.

- Bingham, T. (2010). *The rule of law*. London: Allen Lane
- Bradford-Smith, K. (2012). Supporting a population and housing census in a post conflict fragile country – Democratic Republic of Congo, Paper presented at 17th GSS Methodology Conference, 27 June, London, UK.
- Brackstone, G. (1999). Managing Data Quality in a Statistical Agency, *Survey Methodology*, 25(2), 139-149.
- Breiman, L. (1994). The 1991 Census Adjustment: Undercount or Bad Data? *Statistical Science*, 9(2), 458-475.
- Brown, J., Diamond, I., Chambers, R., Buckner, L., and Teague, A. (1999). A methodological strategy for a one-number census in the UK. *Journal of the Royal Statistical Society: Series A (Statistics in Society)*, 162(2):247-267.
- Cézard, M. and Lefebvre, O. (2008). *Census Quality*. Institut National de la Statistique et des Études Économiques (National Institute of Statistics and Economic Studies) report. Available at: <http://unstats.un.org/unsd/censuskb20/Attachment477.aspx>. Accessed: 22nd June, 2013.
- Champkin, J. (2011). Happy birthday, 7 billionth baby. *Significance*. Available from: <http://www.significancemagazine.org/details/webexclusive/1384961/Happy-Birthday-7-billionth-baby.html>. Accessed: 22nd June, 2013.
- Christopher, A.J. (2005). Race and the census in the commonwealth, *Population, Space and Place*, 11, 103-108.
- Christopher, A.J. (2011). Questions of language in commonwealth censuses, *Population, Space and Place*, 17, 534-549.
- Clanché, F. (2011). France's redesigned census: lessons and prospects. Paper presented at the Conference of the Italian Statistical Society: Statistics in the 150 years from the Unit of Italy, 8-10 June, Bologna, Italy.
- Coleman, D. (2013). The Twilight of the Census. *Population and Development Review*. 38, 334-351.
- de Beer, J., Raymer, J., van der Erf, R. and van Wissen, L. (2010). Overcoming the problems of inconsistent international migration data: a new method applied to flows in Europe. *European Journal of Population*, 26(4), 459-481.
- Department of Statistics Malaysia (DOSM) (2010). *Population and Housing Census of Malaysia 2010*. Available from: http://www.statistics.gov.my/mycensus2010/index.php?option=com_content&view=article&id=52&lang=en&Itemid=60#4. Accessed: 22nd June, 2013.
- Ebulelang, G.K. (2010). Second Population and Housing Census in DRC – A challenge. *Population Censuses in Post Conflict Countries*. 41st Session of the United Nations Statistical Commission, 23-26 February, New York, USA.
- Eurostat (2011). *EU legislation on the 2011 Population and Housing Censuses – explanatory notes*. Eurostat Methodologies and Working Papers. Available from: http://epp.eurostat.ec.europa.eu/cache/ITY_OFFPUB/KS-RA-11-006/EN/KS-RA-11-006-EN.PDF. Accessed: 22nd June, 2013.

Eurostat (2012). A census is a census is a census. Paper submitted for presentation at the Joint UNECE/Eurostat Seminar on the Challenges for Future Population and Housing Censuses. 4-7 June, Paris, France.

Fienberg, S.E. and Prewitt, K. (2010). Save your census. *Nature*, 488, 1043.

Graham-Harrison, E. (2013). Census more than just numbers game in Afghanistan. *The Sydney Morning Herald*. 5th January 2013. Retrieved from: <http://www.smh.com.au/world/census-more-than-just-numbers-game-in-afghanistan-20130104-2c8vm.html>

Hacking, I.M. (1990). *The taming of chance*. Cambridge University Press

Harper, G. and Mayhew, L. (2012). Using Administrative data to count local population. *Applied Spatial Analysis and Policy*, 5(2), 97-122.

Herzog, T.N., Scheuren, F. and Winkler, W.E. (2007). *Data Quality and Record Linkage Techniques*. Springer Verlag.

Higgs, E. (2003). *The Information State in England: The Central Collection of Information on Citizens since 1500*, Palgrave Macmillan.

Hooker, R.H. (1894). Modes of Census-Taking in the British Dominions, *Journal of the Royal Statistical Society*, 57(2), 298-368.

Isaki, C.T, Ikeda, M.M, Tsay, J.H. and Fuller, W.A. (2000). An estimation file that incorporates auxiliary information. *Journal of Official Statistics*, 16(2), 155-172.

Italian Statistical Office (ISTAT) (2012). Experience with address lists and other preliminary work. Paper submitted for presentation at the Joint UNECE/Eurostat Meeting on Population and Housing Censuses. 22-25 May, Geneva, Switzerland.

International Monetary Fund (IMF) (2011). World Economic Outlook Database – Democratic Republic of Congo. Available from: <http://www.imf.org/external/pubs/ft/weo/2011/01/weodata/index.aspx>. Accessed: 22nd June, 2013.

Judson, D.H. (2007). Information integration for constructing social statistics: history, theory and ideas towards a research programme, *Journal of the Royal Statistical Society, Series A*, 170(2), 483-501.

Kish, L. (1979). Samples and censuses. *International Statistical Review*. 47(2), 99-109.

Kertzer, D.I. and Arel, D. (2002) *Censuses, identity formation and the struggle for political power*. In David .I. Kertzer, D.I. and Dominique Arel (eds) *Census and Identity: The politics of race, ethnicity, and language in national censuses*. Cambridge University Press. Cambridge: UK.

Lynn, P. (2003). Developing quality standards for cross-national surveys, *International Journal of Social Research Methodology*, 6(4), 323-336.

Mahon, B. (2009) *Knowledge is Power: A short history of official data collection in the UK*. Commissioned by Karen Dunnell, National Statistician, to mark the 175th Anniversary of the Royal Statistical Society. Crown Copyright.

McCaa, R., Ruggles, S., Sobek, M. and Thomas, W. (2011). IPUMS-International: Free, World-wide Microdata Access now for Censuses of 62 Countries – 80 by 2015. Paper presented at the 58th World Congress of the International Statistical Institute. 21-27 August, Dublin, Ireland.

Missiakoulis, S. (2010). Cecrops, King of Athens: the First (?) Recorded Population Census in History, *International Statistical Review*, 78(3), 413-418.

National Audit Office (2001). *Outsourcing the 2001 census*. HMSO: London.

National Research Council (2009). *Coverage measurement in the 2010 census*. National Academies Press: Washington, DC.

Office for National Statistics (2012). *The Beyond 2011 Programme*. Paper submitted for presentation at the Joint UNECE/Eurostat Seminar on the Challenges for Future Population and Housing Censuses. 4-7 June, Paris, France.

Pierce, C. (2008). The American Community Survey, in Lavrakas, P. (ed.) *The Encyclopaedia of Survey Research Methods*, pages 23-25. Thousand Oaks: SAGE Publications.

Randall, S., Coast, E. and Leone, T. (2011). Cultural constructions of the concept of household in sample surveys, *Population Studies*, 65(2), 217-229.

Redfern, P. (2004). An alternative view of the 2001 census and future census taking, *Journal of the Royal Statistical Society, Series A*, 167(2), 209-228.

Renssen, R.H. and Nieuwenbroek, N.J (1997). Aligning estimates for common variables in two or more samples surveys. *Journal of the American Statistical Association (JASA)*, 92(437), 368-374.

Rusnock, A. (1997). Quantification, Precision and Accuracy: determination of population in the ancient regime, in Wise, M. N. (ed.) *The Values of Precision*, pages 17-38, Princeton University Press: Princeton, NJ.

Schurer, K. and Mills, D.R. (1997). *Local Communities in the Victorian Census Enumerator's Books*, Leopard's Head: Oxford.

Simpson, L. (2007). Fixing the population: from census to population estimate, *Environment and Planning A*, 39, 1045-1057.

Singer, E., Hoewyk, J.V. and Neugebauer, R.J. (2003). Attitudes and Behaviour: The impact of privacy and confidentiality concerns on participation in the 2000 census. *Public Opinion Quarterly*, 67, 368-384.

Statistical Office of the Republic of Slovenia (SORS) (2012). *2011 Register based census in Slovenia – lessons learnt*. Paper submitted for presentation at the Joint UNECE/Eurostat Meeting on Population and Housing Censuses. 22-25 May 2012, Geneva, Switzerland.

Statistics Canada (2012). *Changes in the Canadian Census of Population*. Paper submitted for presentation at the Joint UNECE/Eurostat Seminar on the Challenges for Future Population and Housing Censuses. 4-7 June 2012, Paris, France.

Statistics Netherlands (2012a). *Methodology used for estimating census tables based on incomplete information*. Paper submitted for presentation at the Joint UNECE/Eurostat Meeting on Population and Housing Censuses. 22-25 May 2012, Geneva, Switzerland.

Statistics Netherlands (2012b). Quality of Registers used for the Dutch Census. Paper submitted for presentation at the UNECE-Eurostat Expert Group Meeting on Censuses using Registers. 22-23 May 2012, Geneva, Switzerland.

UK Parliament (2012). House of Commons Science and Technology Committee: The census and social science. Third Report of Session 2012–13. Available from: <http://www.publications.parliament.uk/pa/cm201213/cmselect/cmsctech/322/322.pdf>. Accessed: 22nd June, 2013

UNECE (2006). Conference of European Statisticians Recommendations for the 2010 Censuses of Population and Housing. Published by United Nations Economic Commission for Europe in cooperation with the Statistical Office of the European Communities (Eurostat). United Nations publication: Geneva, Switzerland.

UNECE (2007). Register-based statistics in the Nordic countries: review of best practice with focus on population and social statistics. United Nations publication: Geneva, Switzerland.

UNSD (2008). Principles and Recommendations for Population and Housing Censuses: Revision 2. Published by the United Nations Statistics Division. United Nations publication: New York, USA.

US Census Bureau (2010). Factfinder for the Nation: History and Organisation. U.S. Department of Commerce, Economics and Statistics Administration, Washington D.C., USA.

US Census Bureau (2012). Report of the United States of America on the 2010 World Programme on Population and Housing Censuses, UN Statistical Commission 43rd Meeting, 28 February-2 March, New York, USA.

Uprichard, E. (2013). Sampling: bridging probability and non-probability designs. *International Journal of Social Research Methodology*, 16, 1-11.

Uprichard, E., Burrows, R. and Byrne, D (2008). SPSS as an 'Inscription Device': From causality to description?. *Sociological Review*, 56 (4), 606 – 622.

Valente, P. (2010). Census taking in Europe: how are populations counted in 2010? *Population and Societies*, 467, 1-4.

Yeo, M. (2012). The Rights of Science and the Rights of Politics: Lessons from the Long-form Census Controversy. *Canadian Journal of Sociology*, 37(3), 295-317.

Zhang, L.C. (2011). A unit error theory for register based household statistics. *Journal of Official Statistics*. 27(3), 415-432.