New Evidence on Service Lives of Capital Goods in Italy: Implications for Capital Stock Measurement and TFP Growth

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Abstract

Fixed capital stock has an important role in National Accounts. One of the most important parameters of the PIM are assumptions about the expected services live (SL) of the assets. We present results from a new survey on service lives of Other Machinery and Equipment (OM&E) in Italy. We use newly estimated service lives to calculate the Italian net capital stock and consumption of fixed capital, as well as the productive capital stock and related capital services of OM&E in the non-farm business sector, to explore the sensitivity of such measures with respect to changes in service lives, retirement patterns, age-efficiency and age-price profiles; we also test the sensitivity of capital services to alternative assumptions on the rate of return and we compare capital services with capital stock measures. The goal is twofold: to shed light on some puzzles of the Italian economy as described by current national accounts data (e.g. high capital-labour ratio compared to similar countries); to check to what extent different National account practices across countries might hinder the international comparability of net national income and of wealth and productivity measures.

*The opinions expressed in this paper are the author's own and do not represent the views of the Bank of Italy nor those of Istat. All mistakes should be attributed to the exclusive responsibility of the authors. PRELIMINARY - DO NOT QUOTE

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1 Introduction

Fixed capital stock has an important role in National Accounts. It is one of the components of wealth (as measured in accumulation accounts), it is needed to estimate capital input in the productivity measures and its measurement is strictly connected with that of consumption of fixed capital. The standard approach to estimate capital stock is the Perpetual Inventory Method (PIM) that consists in summing past investments taking into account declines in efficiency and value until assets reach the end of their service lives and are retired. One of the most important parameters of the PIM are assumptions about the expected services live (SL) of the assets. However empirical evidence on SL is scant: only few country have run empirical survey and many National Statistical Institutes rely on second best sources as expert advice, tax lives, company accounts or even other countries estimates (OECD 2009).

In the first part of this paper we present results from a new survey on service lives of Other Machinery and Equipment (OM&E) in Italy that was conducted in 2011 by the Bank of Italy in collaboration with the Italian National statistical institute (Istat). Our analysis is based on the responses for 24 asset categories (4-digit CPA) of the OM&E aggregate provided by the 359 user firms that participated in the survey. We aggregate this information in four asset categories (Hardware, Communication equipment, Furniture and Further OM&E) and four sectors of destination (Services, Manufacturing, Construction and Other industries).

In the second part of the paper we use newly estimated service lives to calculate the Italian net capital stock, as well as the productive capital stock and related capital services of OM&E in the non-farm business sector, both at the aggregate and industry level. We then explore the sensitivity of such measures with respect to changes in service lives (including constant versus time varying service lives), retirement patterns, age-efficiency and age-price profiles (hyperbolic age efficiency profile combined with linear age-price profile versus geometric model); we also test the sensitivity of capital services to alternative assumptions on the rate of return (exogenous versus endogenous) and we compare capital services with capital stock measures. The goal is twofold: to shed light on some puzzles of the Italian economy as described by current national accounts data (e.g. high capital-labour ratio compared to similar countries); to check to what extent different National account practices across countries might hinder the international comparability of net national income and of wealth and productivity measures.

2 Service lives of OM&E in Italy: a new survey

2.1 Description

From July to December, 2011, a survey on service lives of capital goods was conducted among a sub-sample of Italian firms participating in the Bank of Italys annual Survey of industrial and service firms (Invind). As for Invind, contacts and interviews were carried out by the Bank of Italy territorial branches. Here is a summary of the main features of the survey; more details are found in Tartaglia-Polcini (2013). This initiative was made possible thanks to the collaboration of the Italian Statistical Institute (Istat) that contributed to the questionnaires and provided useful information for the computation of the estimates. The initiative was motivated by the need, perceived by both institutions, to investigate in depth the parameters of measurement of capital stock and shed light on some peculiarities of capital formation in Italy. Results encouraged Istat to adopt the newly estimated service lives for official estimates of productivity measures; A natural consequence would be to take on the new estimates also for the computation of official estimates of net capital stock and consumption of fixed capital.[1]

The objective was to collect quantitative and qualitative information on levels and trends of average service lives of some capital goods (chosen within Other Machinery and Equipment - OM&E henceforth) as an update of the estimates currently used for the computation of capital stock. Within Machinery & Equipment, vehicles were excluded as reliable information on their service lives is already available from other sources.

The survey was focused on a subset of categories of capital goods of the type Other Machinery and Equipment (OM&E). The Italian National Institute of Statistics (Istat) selected a list of 24 categories more significantly contributing to the total investment expenditure in OM&E, for which there were no alternative sources of information on service lives and it was deemed that firms could provide reliable information. For this reason the survey excluded transport vehicles, construction goods, software and some other minor OM&E categories.

The sample is a sub-sample of firms already participating in the Bank of Italys annual Survey of industrial and service firms (Invind): industry and service firms with at least 20 employees. Time and cost considerations led to the adoption of a convenience sampling scheme on a fraction (465 firms,

[1] For sake of simplicity in the paper we label as "Istat service lives" service lives adopted to estimate net capital stock and consumption of fixed capital.

slightly more than one tenth) of the total amount of firms available in the Invind sample.

Firms participated in the survey as capital goods users or capital goods producers. Sample size privileged users, considering producers as a small diagnostic sample. 359 firms took and 78 as producers.

Information was collected on 1.710 goods used and 135 goods produced. On average, each participating firm provided answers on 4.8 goods (users) and 1.7 goods (producers).

Interviewers were asked to contact firms having first in mind the maximum possible variety in capital goods (hence achieving some variety across user sectors) and only secondly across firm size. Localization of interviewers (the Bank of Italy territorial branches) assured geographical variety. Firms, on their part, were asked to provide data on the maximum variety of goods they used (produced). Selection was constrained only by firms availability to take part. No direct control on typical Invind stratification variables (size-sector-geographical area) was held; nonetheless, the ex post composition of the sample does not appear very different from the original Invind sample.

The survey design could not control for the composition of goods within the different user sectors (this would have required a detailed knowledge of the number of capital goods in the economy and would have posed formidable practical problems): firms were asked to give information about the most valuable goods they used (produced).

Users were asked for: a) an evaluation of the useful service lives of the capital goods they employed, dismissed either for obsolescence or having been sold abroad; b) the expected service lives of the new capital goods purchased in the same period; c) a qualitative trend in useful service lives, as perceived in the recent decade. Producers were asked for a) the expected service lives of the capital goods produced in the last five years; b) a qualitative trend of the same, as perceived in the recent decade.

2.2 Service lives: evidence from the survey and comparison over time

Survey estimates are shown in Tables 1 and 2, following standard aggregations of goods and user sectors. Users report that discarded computers lived some 6 years, with little differences across firm size and sector; communications equipment lived a bit longer (7 years) especially in manufacturing (9 years). Furniture is discarded after 13 years, whereas Further OM&E is reported having lasted on average 14.5 years. Past lives of Further OM&E are shorter in Service and Costruction (about 9 years) due to the different composition of goods in this category between sectors. Service lives of Further OM&E employed by industrial firms appear longer than those in the remaining sectors; this is especially true for other industry excluding construction (Energy and Extraction). Estimates appear not to be significantly linked to firm size, whereas by geographical area they reflect the location of firms operating in a particular sector.

Survey estimates of expected user service lives appear slightly shorter than past lives; the difference reaches almost 1 year for Furniture overall. Answers about expected service lives appear broadly coherent between users and producers (correlation coefficient among CPA4 [2] goods is 0.85). Producers expected lives appear, on average, a little longer than the correspondent expectations from users.

Our results suggest a declining trend in service lives, on two lines of comparison. First, survey estimates of discards could be considered a sort of update of the estimates employed by Istat in the National Accounts. In fact, Istat SL were set by Istat approximately in 1990 referring to SL of assets discarded at that time. This reveals lives shorter of about 3 years overall, concentrated particularly in computers, furniture and Further OM&E. That is 15-20 per cent shorter. Differences are more marked for Further OM&E in Services and Construction: survey estimates suggest averages of around 9 years, against the level of 18 years adopted. In contrast, lives for communications equipment in Manufacturing appear longer (9.4 years) than the standard assumed level of 7. Second, the fact that expected lives appear even shorter than discards is definitely consistent with a declining tendency. This is also confirmed by the qualitative answers on trend provided by the firms.

The issue of a possible downward trend of service lives is broadly perceived in the national accounts literature, but seemingly not intensely investigated. Blades (1983) cites some studies tackling this issue, often dating back to 1970s: for example, Atkinson and Mairesse (1978) in France, Tengblåd and Westerlund (1976) in Sweden, Lützel (1977) in West Germany, all found evidence of a decline in service lives.

To the best of our knowledge, it is possible to find only indirect suggestions of decreasing service lives in recent works: e.g. Görzig (2007) devotes part of his paper to measurement of service lives: implicit average service lives averaged on the whole economy show a possible decline in a number of countries.

[2] 4-digit classification of products by activity (CPA)

Table 1: Service lives by standard aggregations of OM&E

CPA1[1]		Service life of goods							
		Istat[2]	Retired			New (forecast)		Trend[8]	
			Discard[4] Users	Export[5] Users	Total[6] Users	Users	Producers[7]	Users	Producers[8]
2620	HDW	7.0	5.8	5.4	5.7	5.1	5.4	−5.7	2.9
2630	TLC	7.0	6.8	6.0	6.6	6.4	9.0	−0.2	−4.8
3100	Furniture	16.0	13.2	7.9	12.6	12.3	11.4	−3.0	−1.4
	FOM&E [3]	18.0	14.5	10.9	13.8	14.1	15.3	−1.3	0.7
Total		16.5	13.4	9.9	12.8	12.9	13.7	−1.8	0.4

[1] Categories of Other Machinery and Equipment surveyed, based on the CPA classification customized for the aims of the survey. – [2] All other OM&E surveyed. – [3] Service lives currently used in National accounts. See Istat (2007). These are fixed across user sectors; for furniture, service life is 16 years except in trade and accommodation services (12 years). Total is not provided by Istat; it is computed here for comparison only, as a mean of the category values weighted with the corresponding investments. – [4] Because they reached the end of their productive life or for economic obsolescence. – [5] Retired because exported. –
[6] Retired or exported (average of the two preceding columns, weighted with the estimated proportions based on sample size, assuming all goods equal, with constant value and efficiency over time). –
[7] Estimates of categories 2620, 2630, 3100 for producers are based on a very tiny sample size and should be considered only as indicative. – [8] Qualitative answers (independent of those on length of service lives) indicating perceived direction and intensity of service life change throughout the preceding ten years, made quantitative as follows: -20=strong decrease; -10=decrease; 0=no change; 10=increase; 20=strong increase.

Table 2: Service lives by user sector

User sector[1]	**Service life of goods**							
	Istat[2]	**Retired**			**New (forecast)**		**Trend**[7]	
		Discard[3] Users	Export[4] Users	Total[5] Users	Users	Producers[6]	Users	Producers[6]
Industry excl. construction	16.5	16.1	10.7	15.5	14.6	13.7	−1.7	0.4
of which: Manufacturing	16.5	14.9	10.9	14.3	13.3	13.7	−1.7	0.4
Services	16.5	9.0	8.3	8.8	10.4	–	−1.9	–
Construction	16.5	9.7	10.0	9.7	9.1	–	−1.3	–
Total	16.5	13.4	9.9	12.8	12.9	13.7	−1.8	0.4

[1] Sectors of economic activity. – [2] Service lives currently used in National accounts. See Istat (2007). These are fixed across user sectors; for furniture, service life is 16 years except in trade and accommodation services (12 years). Total is not provided by Istat; it is computed here for comparison only, as a mean of the category values weighted with the corresponding investments. – [3] Because they reached the end of their productive life or for economic obsolescence. – [4] Retired because exported. –
[5] Retired or exported (average of the two preceding columns, weighted with the estimated proportions based on sample size, assuming all goods equal, with constant value and efficiency over time). –
[6] Estimates for producers are based on a very tiny sample size and should be considered only as indicative. –
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Although most countries seem to keep asset lives fixed over time when estimating capital stock, there are some exceptions. The following information is taken from OECD (2009). In United Kingdom, the lives of most assets are assumed to have been gradually declining since the 1950s and service lives of most types of long-life assets are reduced by about 1 per cent each year. The Statistisches Bundesamt uses declining service lives for housing, farm buildings, motor vehicles and some industrial equipment. Finland assumes falling service lives, by 0.8-1 per cent yearly from 1960 to 1989 and at about 0.4-0.5 per cent since 1990. Also the Australian Bureau of Statistics (1997) reduces the mean asset lives of equipment by 5 per cent per decade.

As a matter of fact, when comparing aggregate average service lives over time it should be kept in mind that an observed decline could be due to two distinct drivers at work. On one hand, lives of cohorts of the same types of goods could effectively shorten over time: this is the phenomenon it would be ideal to detect. On the other hand, implicit average service lives could also shorten because firms, over time, shift their investments to higher quotas of shorter-lived assets (e.g. from Other Machinery to computers). The advantage of the present survey is that it is aimed precisely at measuring lives, observed and expected, for approximate cohorts of goods or narrow categories of goods, at the firm level, allowing then for direct comparison over time.

2.3 Retirement patterns

Data collected within the present survey provide a way of estimating the retirement patterns. The distribution of retirement is relevant since, for given mean service lives, individual assets in the same cohort may cease service before or after the mean age and this variability affects the capital stock. Retirement patterns can be directly approximated by the sampling distribution of the corresponding variables, if we assume that the variability across goods and firms is able to reproduce the variability across time. This assumption, recalling that of ergodicity in time series, would be acceptable in the absence of a trend; in our case we find a measurable shift between past lives and expected future lives, that, although not direct evidence of trend, requires repeating the exercise separately for discards and acquisitions.

We test compatibility of the empirical distributions to some of the more common shapes adopted in National accounts (Normal, Lognormal or Weibull; the parameters are estimated via Maximum Likelihood). We use standard aggregations of goods, separately for manufacture, other industry excluding construction, services and construction and aggregations of these.

Graphical patterns are shown in Figures 3, 4, 5, 6. Almost all distributions show positive skewness of some degree. A battery of standard goodness-of-fit tests are run, showing that a lognormal pattern fits the data overall better in comparison to other shapes, also where a normal fit could not be rejected (Tartaglia-Polcini, 2013). This is also graphically suggested by the closeness of the lognormal and the kernel patterns. Some evidence of heaping in the data does not hamper our conclusions: since the effect on the tests would be to lead to more frequent rejections, the statistical significance of the tests could be therefore underestimated in our case.

Despite the presence of trend in the data, due to the observed decline in service lives, there are no apparent differences in conclusions that can be drawn from the tests on discards as compared to those on acquisitions.

Finally, a test was run to check whether survey data are compatible with the standard Istat assumptions on the shape of the retirement patterns: a truncated normal distribution with location parameter SL equal to the given service life, truncation parameters $a = SL - 0.35SL$ and $b = SL + 0.35SL$, scale parameter σ such that the probability mass included in the interval $[SL \pm 0.25SL]$ adds up to 0.9. A Kolmogorov-Smirnov test shows that the assumed shape is rejected by survey data.

3 Measuring capital stock, consumption of fixed capital and capital services, conceptual framework

The capital stock may be defined either as a measure of wealth, or as a measure of input to production. In the first case it is referred to as *net capital stock* or *wealth capital* (NCS), in the second case as *productive capital* (PCS). Here we provide a brief description of the methodology generally employed in national accounts to construct these and other related capital measures. A detailed exposition can be found in OECD (2009).

Construction of the NCS rests on the application of the *perpetual inventory method* (PIM):

$$\mathrm{NCS}_t = \sum_j \sum_m \mathrm{NCS}_t^{m,j} = \sum_j \sum_m \sum_{s=0} \eta_{s,t}^{m,j} \mathrm{GFCF}_{t-s}^{m,j} \tag{3.1}$$

For each asset class, m, and sector of destination, j, the net capital stock at time t, $\mathrm{PCS}_t^{m,j}$ is not measured directly, rather it is inferred by cumulating past investment flows (or *gross fixed capital formation*, in current currency units, $\mathrm{GFCF}_{t-s}^{m,j}$) using appropriate age (and possibly time) specific weights, ($\eta_{s,t}^{m,j}$, which reflect the lower contribution of older cohorts of investment to the current stock of wealth. Such series of weights is referred to as the *combined age-price/retirement profile*.

The combined age price/retirement profile, $\eta_{s,t}^{m,j}$, has two components. The first component is the retirement profile. An asset, think of a truck in the construction sector, is viable for a certain amount of time before it is scrapped and different copies of a same asset may have a different life span, due for example to accidental damage.

The average life span of a particular asset class in a particular sector of destination is referred to as *service life* (SL) and the corresponding distribution as the *retirement distribution*. The resulting survival function, called *the retirement profile*, is used to discount different cohorts of investments which are then cumulated to obtain the *gross capital stock* (GCS).

$$\mathrm{GCS}_t = \sum_j \sum_m \mathrm{GCS}_t^{m,j} = \sum_j \sum_m \sum_{s=0} \sigma_{s,t}^{m,j} \mathrm{GFCF}_{t-s}^{m,j} \tag{3.2}$$

where $\sigma_{s,t}^{m,j}$ denotes the survival function.

The second component of $\eta_{s,t}^{m,j}$ is the age-price profile. GFC is a measure of the assets still in existence at that point in time, valued at the price of purchase (in current currency units). Since the (real) price of an asset generally declines with age, the GFC is not a measure of wealth. Depreciation should reflect both physical deterioration and normal obsolescence – a two year old personal computer may be as efficient as at the time of its purchase, but looses value as better models become available. Instead, obsolescence due to unforeseen technological breakthroughs – the typewriter that is replaced by personal computers – and changes in relative prices – an energy intensive machines becoming uneconomical due to an energy price shock – are generally accounted for as "other changes in the volume of assets", together with losses due to natural disasters. The pattern of price decline as the asset ages is captured by the *age-price profile*, which is equal to the ratio between the price of an asset of a particular age and the price of a new copy of the same asset, in the same period. Finally, *depreciation*, or *consumption of fixed capital* at time t is defined as the difference between the gross and the net capital stock, $\mathrm{CFC}_t = \mathrm{GCS}_t - \mathrm{NCS}_t$.

The productive stock for a particular asset class m and sector of destination j at time t, $\mathrm{PCS}_t^{m,j}$ is constructed in the same manner as $\mathrm{NCS}_t^{m,j}$, except that the age-efficiency profile is used in place of the age-price profile.

The age-efficiency profile reflects the decline in the flow of productive services delivered by the asset due to its physical deterioration over time. The age-price profile and the age-efficiency profile are theoretically related to one another, because the price of an asset equals the present value of the future services it delivers (net of capital gains or losses). Indeed, if both profiles decline at a constant rate, then the rate of decline must be the same and $\text{NCS}_t^{m,j}$ and $\text{PCS}_t^{m,j}$ coincide. Such a special case turns out to provide a good empirical fit, as both the combined age-price/retirement profile and the combined age-efficiency/retirement profile generally follow a near-geometric pattern for a variety of commonly used retirement distributions, even when the age-efficiency profile is concave – such as in the case of hyperbolic efficiency decline (OECD (2009)). [3]

Differently than for the NCS, the aggregate PCS is not well defined, as each asset category/sector of destination combination may deliver a different flow of services to production. Given $\text{PCS}_t^{m,j}$, it is assumed that the corresponding flow of services is proportional. Then the aggregate flow of capital service to production (FCS_t) can be constructed by adding the individual contributions to the flow coming from each asset category and sector of destination:

$$\text{SF}_t = \sum_j \sum_m \varsigma_t^{m,j} \text{PCS}_t^{m,j} = \sum_j \sum_m \varsigma_t^{m,j} \sum_{s=0} \pi_{s,t}^{m,j} \text{GFCF}_{t-s}^{m,j} \tag{3.3}$$

where $\pi_{s,t}^{m,j}$ is the combined age-efficiency/retirement profile. The factor of proportionality $\varsigma_t^{m,j}$ is referred to as the *unit user cost*. It is conceptualized as the cost for a firm of buying an asset and selling it back at the end of the same period, accounting for the opportunity cost of tying up the financial capital and under the assumption of competitive markets (no extra profits).[4] The unit user cost at time t of a new asset ($s = 0$) is then equal to:

$$\begin{aligned}\varsigma_t &= p_{0,t}(1 + r_t) - p_{1,t+1} = p_{0,t}(1 + r_t) - p_{0,t}(1 - \delta_{0,t})(1 + i_t) \\ &\approx p_{0,t}(r_t + \delta_{0,t} - i_t) \end{aligned} \tag{3.4a}$$

[3] The geometric approach has been adopted by the United States Bureau of Economic Analysis and is recommended by the OECD Manual on Measuring Capital (OECD (2009))

[4] The service flow can be alternatively conceptualize taking the income perspective, or the market perspective. The former gives rise to the notion of *price of capital services* – which is equal to the present value of current and future services delivered to production by the asset; the latter leads to the definition of *rental price*, which is equal to the price of leasing the asset. In a frictionless world the three approaches are equivalent – see OECD (2009).

where p_0^t is the price of the asset at time t, r^t and i^t are the real market rate of return and the price change of the asset at time t, respectively, and δ_0 is the depreciation rate of a new asset.[5]

The rate of return may reflect agents' expectations about the required return from investment (ex-ante rate of return) or based on market outcomes (ex-post rate of return). The ex-post rate of return can be exogenous and, say, equal to the rate on corporate debt, or endogenous and set so that the value of capital services equals the gross operating surplus in each sector, or for the economy as a whole.

4 Sensitivity analysis

4.1 Methodology in Italian national accounts

The Italian national statistical institutes assumes that service lives are constant over time; the retirement distribution is a truncated normal; the truncation limits are set at ±35% of SL and the variance is set so that 90% of retirements occur between ±25% of SL. The age-efficiency profile is hyperbolic, $(SL - s)/(SL - \beta s)$, with parameter $\beta = 0.5$ in the case of Furniture and FOM&E and $\beta = 0.75$ in the case of Hardware and of Telecommunication equipment. The real rate of return in the user cost formula (3.4a) is set endogenously so that the service flow is equal to the aggregate operating surplus from the national accounts.

In this section we assess the sensitivity of capital estimates (and, correspondingly, of TFP measurement) to changes in this methodology. First we employ the newly estimated SL reported in table 1. Next, survey results suggest that SL may have declined over time, thus we analyze how such a decline may affect capital stock estimates under several declining patterns. Finally we study the impact of changes to other assumptions made in current Italian national account practices concerning retirement patterns, age-efficiency profiles and the rate of return.

4.2 Constant service lives

In table 3 we report the NCS level in 1990 and 2011 computed using Istat methodology and Istat SL and the newly estimated SL (see table 1). Figures are aggregated by asset class and sector of use (plots of the corresponding series are reported in the appendix).

[5] r and i may be expressed in real or nominal terms, since they have opposite signs.

Table 3: NCS by asset class and sector of use

Component	**SL**	**level**			**share**		
		1990	2011		1990	2011	
(by asset class)							
FOME	Istat	386724	604298	56%	86.7%	86.6%	−0.1
	new	320631	484356	51%	86.2%	86.0%	−0.2
		-17.1%	-19.8%				
HW	Istat	13540	21949	62%	3.0%	3.1%	0.1
	new	11067	17356	57%	3.0%	3.1%	0.1
		-18.3%	-20.9%				
TLC	Istat	10597	16585	56%	2.4%	2.4%	0.0
	new	10183	15915	56%	2.7%	2.8%	0.1
		-3.9%	-4.0%				
Furniture	Istat	35361	55361	57%	7.9%	7.9%	0.0
	new	30011	45417	51%	8.1%	8.1%	0.0
		-15.1%	-18.0%				
(by sector)							
Manifact.	Istat	278693	361866	30%	62.5%	51.8%	−10.6
	new	244405	312559	28%	65.7%	55.5%	−10.2
		-12.3%	-13.6%				
Utilities	Istat	29951	57140	91%	6.7%	8.2%	1.5
	new	34647	72534	109%	9.3%	12.9%	3.6
		15.7%	26.9%				
Construc.	Istat	23353	33911	45%	5.2%	4.9%	−0.4
	new	12804	21090	65%	3.4%	3.7%	0.3
		-45.2%	-37.8%				
Services	Istat	114225	245276	115%	25.6%	35.1%	9.5
	new	80036	156860	96%	21.5%	27.9%	6.3
		-29.9%	-36.0%				

Table 4: Capital measures, average annual rate of growth (*100), impact of new SL

	1990 1995	1995 2000	2000 2005	2005 2010	1990 2011	2007 2011
NCS, OM&E						
Istat	2.4	2.8	2.2	1.6	2.2	0.7
New SL	2.2	2.9	2.1	1.2	2.0	0.2
SF, OM&E						
Istat	2.4	2.8	2.2	1.6	2.2	1.0
New SL	2.0	2.9	2.2	1.4	2.0	0.5
SF, aggregate						
Istat	2.6	3.2	2.8	1.4	2.4	0.8
New SL	2.4	3.3	2.9	1.3	2.3	0.5
TFP impact wrt Istat SL						
New SL	0.1	0.0	0.0	0.0	0.0	0.1

A change in SL implies a revision of the level of the NCS in the same direction. The table shows that the NCS of OM&E is revised downward for all asset classes and sectors, except the utilities, the revision being particularly significant for services and construction (−36 and −37.8% in 2011, respectively). The share of the service sector in 2011 is reduced from 35.1 to 27.9%, that of manufacturing increasing from 51.8 to 55.5% (the share across asset classes remains instead essentially the same). The secular shift in the composition of the NCS towards services is also reduced markedly, the share increasing from 21.5 to 27.9% between 1990 and 2011, instead of from 25.6 to 35.1%.

The total NCS of OM&E in 2011 is revised downward by 19.4%. The downward revision of the NCS helps reconciling figures from the Italian national accounts on the rate of return on capital and on capital intensity with those for other countries. Italy has traditionally being regarded as a country with a relatively high capital intensity and yet a relatively low rate of return on capital (Brandolini and oth., 2009).

In table 4 we report the average annual growth of (chained) NCS, of SF from OM&E and of total SF; moreover we report the impact of adopting new service lives on TFP growth. In table 5 we present the impact on cumulated rate of change of NCS and SF. Adopting new service lives affects only marginally the dinamics of capital measures over the whole period 1990-

Table 5: Capital measures, cumulated change (%), impact of new SL (ppt)

	1990 1995	1995 2000	2000 2005	2005 2010	1990 2011	2007 2011
NCS, OM&E						
Istat	12.6	14.7	11.7	8.1	56.8	3.0
New SL	−0.8	0.8	−0.8	−2.1	−5.1	−2.4
SF, OM&E						
Istat	12.8	15.0	11.4	8.2	57.8	4.0
New SL	−2.7	0.5	−0.1	−1.2	−5.9	−2.0
SF, aggregate						
Istat	13.7	16.9	15.0	7.3	64.9	3.1
New SL	−1.2	0.5	0.2	−0.6	−2.0	−1.0

2011: the average rate of growth is equal to 2,0 per cent instead than 2,2 per cent (the cumulated growth is reduced by 5.9 percentage points, from 57.8 to 51.9%). The impact on SL from OM&E is very similar to the impact on NCS. However OM&E is only one of the components of productive capital and the overall impact on aggregate service flows is lower than the impact on SF from OM&E: the average growth is equal to 2.3 per cent v.s 2.4 per cent obtained using Istat service lives (cumulated growth is reduced by −2.0 percentage points). The small impact on total SF becomes negligible in terms of impact on TFP growth, because capital is only one of the factors contributing to production: the cumulated effect on aggregate TFP growth over the period 1990-2011 is −0.4 percentage points only.

As expected, reducing SL has a greater impact business cycle frequencies. In fact, smaller values of SL imply that productive capital is more sensitive to current changes in investments, increasing the volatility and the prociyclicality of the stock. This is evident during the recent recessionaty period 2007-2011 when the average growth of both NCS and SF from OM&E reduces by 0.5 percentage points; the impact on OM&E is large enough to carry on total SF.

While changes in the level of SL do not impact much on the dynamic of the stock and SF, other things equal, time varying SL may lead to large changes. In the next one we consider the case of time varying service lives.

4.3 Declining service lives

As discussed in Section 2.2, the results from the survey conducted by the Bank of Italy in collaboration with Istat suggest that SL may have decreased over time: the SL of discarded assets between 2005 and 2010 is generally larger than the SL expected for assets purchased over the same period. In addition a statistically significant majority of interviewees report SL to have declined over time when asked to provide a qualitative judgement. In this section we aim at providing an indication on the impact that such a pattern might have on capital related measures and TFP estimates by means of three simple simulation exercises. We informed each of these exercises based on different sources of information. First, we interpolate data on the SL of discarded and purchased assets obtained from the survey (exercise 1).[6] Second, we assume that the SL used by Istat correctly applied to assets discarded up to the year when the parameter for that asset category was set and use this assumption to extend exercise 1 back in time (exercise 2).[7] Below, we refer to these three exercises as $disc \rightarrow purc$ and $Istat \rightarrow disc \rightarrow purc$ respectively. Results for the NCS, and SF of OM&E and aggregate SF are displayed in table 6 as average annual rates of growth and in table 7 as percentage point deviations from those obtained when using Istat SL; in table 6 we also report the impact on TFP growth with respect to the estimates obtained using Istat constant service lives.

The dynamics of capital measures for the aggregate OM&E are significantly tempered when using declining SL. Over the whole period 1990-2011 both the reduction in average growth for NCS and SF of OM&E is equal to 0.5 percentage points in exercise 1 and 0.7 ppt in exercise 2 (the reduction in cumulative growth for the NCS of OM&E is 12.9 ppt in exercise 1 and 21.5 ppt in exercise 2, that of SF is 15.9 and 20.5). The impact is large enough to carry on total SF, with a reduction of average growth equal to 0.2 ppt in exercise 1 and 0.8 in exercise 2. The impact on aggregate TFP is weaker but not negligible, with a reduction of 0.1 ppt in exercise 1 and 0.2

[6] the SL of an asset discarded in t refers to an asset purchased in $t - SL^{discarded}$. The survey asked about service lves of assets discarded between 2005 and 2010; we choose 2007 as the reference year and assume that the SL for a particular asset/sector cohort was constant and equal to $SL_{a,s}^{discarded}$ before $2007 - SL_{a,s}^{discarded}$ and then decreased linearly so as to be equal in 2007 to the expected value reported for newly purchased assets, $SL_{a,s}^{purchased}$.

[7] The SL for Furniture and FOM&E was set by Istat in 1990, that for Computers and TLC in 2000. For these exercises we aggregate SL at the asset category level, since Istat uses the same SL across sectors.

Table 6: Variable SL, average annual rate of growth (*100)

	1990 1995	1995 2000	2000 2005	2005 2010	1990 2011	2007 2011
NCS, OM&E						
Istat	2.4	2.8	2.2	1.6	2.2	0.7
disc-purc (ex. 1)	2.2	2.8	1.9	0.6	1.7	−0.6
Istat-disc-purc (ex. 2)	1.5	2.0	1.5	1.1	1.5	0.1
SF, OM&E						
Istat	2.4	2.8	2.2	1.6	2.2	1.0
disc-purc (ex. 1)	2.0	3.0	2.0	0.4	1.7	−0.9
Istat-disc-purc (ex. 2)	1.9	2.1	1.3	1.0	1.5	0.2
SF, aggregate						
Istat	2.6	3.2	2.8	1.4	2.4	0.8
disc-purc (ex. 1)	2.4	3.3	2.8	0.8	2.2	−0.2
Istat-disc-purc (ex. 2)	2.0	2.4	2.0	0.9	1.7	0.2
TFP impact wrt Istat						
disc-purc (ex. 1)	0.1	0.0	0.0	0.2	0.1	0.3
Istat-disc-purc (ex. 2)	0.2	0.2	0.3	0.2	0.2	0.2

Table 7: Variable SL, ppt deviation from Istat (cumulated change)

	1990 1995	1995 2000	2000 2005	2005 2010	1990 2011	2007 2011
NCS, OM&E						
Istat	12.6	14.7	11.7	8.1	56.8	3.0
disc-purc (ex. 1)	−0.9	+0.4	−1.9	−5.3	−12.9	−5.2
Istat-disc-purc (ex. 2)	−4.7	−4.5	−3.8	−2.6	−21.5	−2.5
SF, OM&E						
Istat	12.8	15.0	11.4	8.2	57.8	4.0
disc-purc (ex. 1)	−2.7	+0.7	−0.9	−6.1	−15.9	−7.6
Istat-disc-purc (ex. 2)	−2.7	−3.9	−4.6	−3.2	−20.5	−3.0
SF, aggregate						
Istat	13.7	16.9	15.0	7.3	64.9	3.1
disc-purc (ex. 1)	−1.3	+0.5	−0.3	−3.0	−8.1	−3.8
Istat-disc-purc (ex. 2)	−3.4	−4.1	−4.5	−2.8	−21.4	−2.4

in exercise 2. As mentioned, this is expected, as the survey covers only one of the component of the productive capital stock, and the capital is only one of the factor entering production. However, the effect over the recent recessionary period 2007-2011 is not small: introducing declining SL changes the dynamic of NCS and SF from OM&E from positive to negative in exercise 1, with an increase in TFP growth of 0.3 ppt (under exercise 2 the impact on TFP growth is 0.2 ppt).

These results are indicative, as the available information only provide indirect evidence that SL have varied over time, evidence derived comparing SL of discarded assets with expected SL of purchased asset in the same period. Yet, the changes implemented in exercises 1 and 2 are quite small - less than 1% a year - and the effects on the dynamic of capital related measures is significant. Also it carries out to TFP estimates. Thus we conclude that timely and precise measurement of SL may be important for capital and TFP measurement over short as well as long horizons. In particular, great effort should be devoted to collect information consistent over time that is needed to infer information on the dynamic of SL over time.

4.4 Retirement patterns, efficiency profile, rate of return

We finally consider the effect on capital measurement of changing other assumptions made in Istat methodology. We take the view that, over the entire period 1990-2011, the SL derived using data from the new survey are better estimates of actual SL than those used by Istat. Thus, we use the newly estimated SL as a benchmark and discuss the additional effects of changing other assumptions in Istat methodology one at a time. Results are then to be interpreted as the additional changes that could be expected by altering assumptions in Istat methodology beyond changing SL. Also, for sake of brevity we focus the discussion on SF of OM&E.

Table 8 displays in the first row the cumulated change of SL of OM&E over different sub-periods, including the recent recessionary period 2008-2011. The second row displays percentage point deviations from such figures when using the newly estimated service lives. Such simulation is used as benchmark and the rows below display percentage point deviations from the results for such simulation, thus providing an indication of the additional effects that can be expected from changing assumptions on top of updating SL to the newly estimated values. In particular we consider changes in assumptions concerning retirement patterns, efficiency profiles and the rate of return. As mentioned in section 4.1 Istat assumes that retirements

Table 8: Retirement pattern, efficiency profile, rate of return: effect on service flow from OM&E (cumulated change)

	1990 1995	1995 2000	2000 2005	2005 2010	1990 2011	2007 2011
Istat (percentages)	12.8	15.0	11.4	8.2	57.8	4.0
New SL (ppt dev. from Istat)	−2.7	0.5	−0.1	−1.2	−5.9	−2.0
Retirement patters (ppt dist. from New SL)						
truncation	0.0	0.0	0.0	0.0	0.0	0.0
variance	0.0	0.0	0.0	0.0	0.0	−0.1
trunc. var.	0.0	0.0	0.0	0.0	0.1	0.0
Efficiency profiles						
linear	−1.8	0.0	−0.9	−1.0	−5.2	−1.2
one-hoss shay	2.2	−1.1	2.1	2.5	9.1	2.9
Geometric						
geometric	−0.6	0.5	−0.8	−0.3	−1.4	−0.3
Rate of return						
a priori	1.2	0.6	0.1	−0.1	2.4	−0.2

are normally distributed with mean equal to SL, truncation limits equal to ±35% of SL and the variance set so that 90% of retirements occur between ±25% of SL. We change these assumptions considering the case where the truncation limits are widened to ±60% (*truncation* in the table) and the variance is increased, so that 90% of retirements occur between ±35% of SL (*variance*). Because the distribution originally considered by Istat displays little dispersion, changing the truncation limits does not affect the results significantly. Therefore we also consider the case where the truncation limits and the variance are changed simultaneously (*trunc. and var.*). Next, Istat assumes that efficiency declines following an hyperbolic pattern, $(SL - s)/(SL - \beta s)$, s being the age of the asset and $\beta = .5$ for Furniture and FOM&E and $\beta = .75$ in the case of Hardware and TLC. We test the importance of these restrictions by considering the case where $\beta = 0$ and efficiency declines linearly (*linear* in the table) and that where $\beta = 1$, so that efficiency remains constant at the initial level for the whole time that the asset is in use and drops to 0 at the time of retirement (*one-hoss shay*). We then consider the case of the geometric model (*geometric* in the table). Usually it is assumed that this profile accounts both for efficiency decay and for retirements, so that no explicit retirement function is required for its implementation. For each asset, the geometric rate has been calculated as the ratio of declining balance rate to average service life. The declining balance rate has been set to 0.97 for construction works and to 1.65 for all other assets. Finally, with regard to the rate of return we consider the case where it is set exogenously and equal to 4.0% (*a priori r.r.* in the table)

The impact of the above simulations ranges from negligible to very small.

5 Conclusions

In this paper we have presented results from a new survey on service lives of Other Machinery and Equipment (OM&E) in Italy that was conducted in 2011 by the Bank of Italy in collaboration with the Italian national statistical institute (Istat). Users report that discarded computers lived some 6 years; communications equipment lived a bit longer (7 years) especially in manufacturing (9 years). Furniture is discarded after 13 years, whereas Further OM&E is reported having lasted on average 14.5 years. Moreover, results vary across industries (with the exception of computers that show little differences across sector). For example, we find the service life for (discarded) Further OM&E to be 15.4 years in manufacturing and 9.1 years in services. The results for Further OM&E differ from the assumption currently used by Istat in national accounts estimates of net capital stock, where Istat assumes 18 years in all industries (instead capital input estimates that Istat uses in its productivity measures are based on the the results of this survey).

Assuming that the variability across firms approximates the variability over time, we use discard data to test for alternative parameterizations of the retirement distribution and find the log-normal and the Weibull to deliver the best fit. Finally, the analysis of the data do not counter the hypothesis, well spread in the literature, that service lives have been declining over time: estimates for discarded assets tend to be larger than those for purchased assets.

On the basis of the new evidence on service lives, the net capital stock of OM&E in the non-farm business sector in 2011 appears to be overestimated by 19.3 per cent with respect to the level obtained using Istat service lives. The finding indicates that the statistic is highly sensitive to differences in service lives. It also suggests that the fact that Italy has a high capital-labor ratio compared to similar countries may be partly due to a positive bias in the estimation of the net capital stock. Also, chained net capital stock of OM&E would exhibit stronger pro-cyclicality. As to the recessionary period 2007-2011, we calculate that the stock could have increased by 0.2 percent a year, instead of 0.7 as measured using current national accounts service lives. On the other hand, new service lives do not appear to have affected significantly the average growth over the whole period 1990-2011.

The survey provides evidence that service lives have been declining over time. Our simulations shows that even assuming quite small changes in service lives (less than 1 per cent a year), the dynamic of capital measures for the OM&E aggregate is significantly tempered when using declining service lives. Correspondingly that of aggregate TFP is enhanced. The annual average growth over the period 1990-2011 of chained net capital stock and of service flow is reduced by 0.5 percentage point; even more interestingly, as to the recessionary period 2007-2011, we calculate that the stock could have decreased by 0.6 percent a year, instead of increasing by 0.7 percent a year as measured using current national accounts service lives. The impact on service flow from OM&E is even larger, since adopting declining service lives reduces its average annual growth from 1.0 to -0.9 percent a year.

The impact on aggregate TFP is small but not negligible: over the whole period 1990-2011 introducing declining service lives increases TFP growth by 0.1 percentage point per year; the impact over the recent recessionary period 2007-2011 is larger, being equal to 0.3 percentage point per year. Overall the findings do not support the hypothesis that the stagnant TFP experimented by the Italian economy since 2000 is to a large extent the effect of measurement errors in capital stock of OM&E, although introducing declining service lives makes TFP dynamic less stagnant. Finally, from a genuinely methodological point of view, the survey showed the importance of differentiating service lives by user sector, and the need to regularly update the levels of service lives over time. In particular, great effort should be devoted to collect information consistent over time that is needed to infer information on the dynamic of service lives over time.

Figure 1: Constant service lives

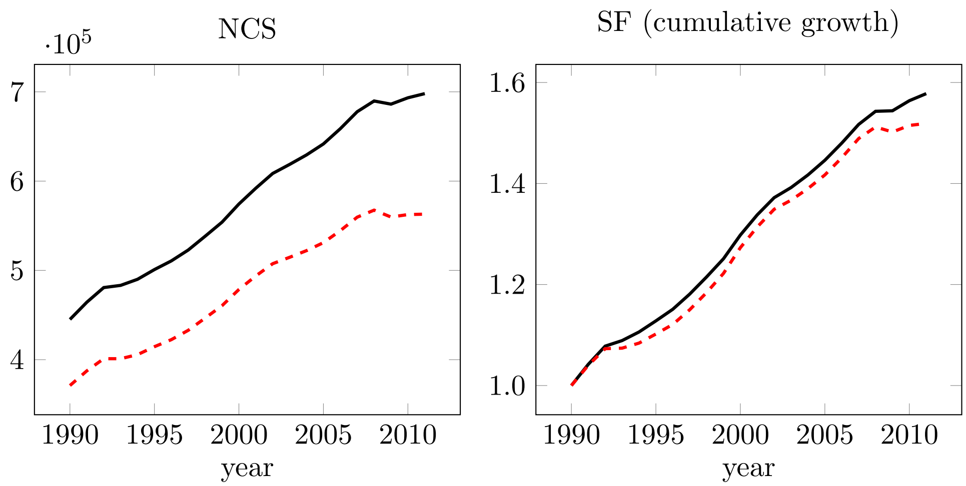


Figure 2: NCS with new SL and Istat SL by asset class and sector

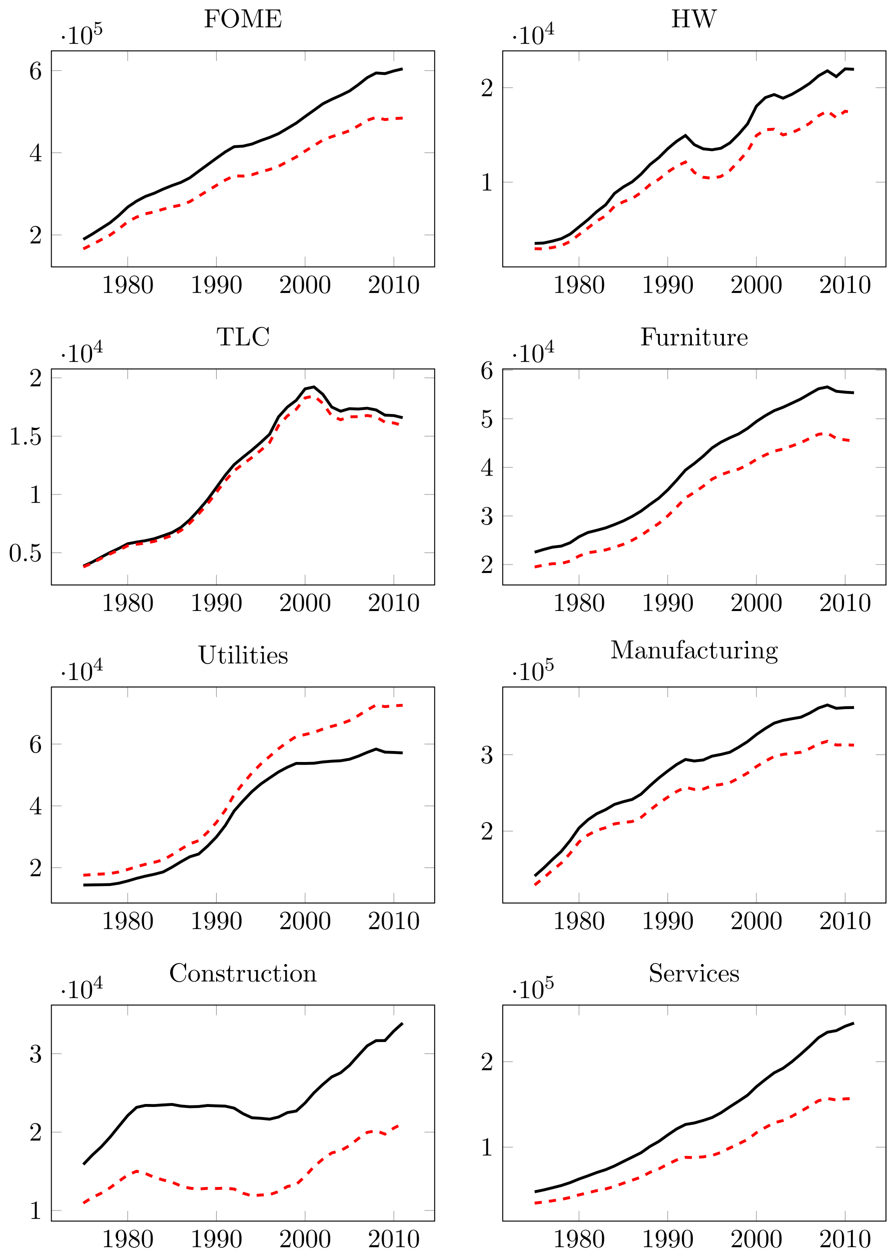


Figure 3: Retirement patterns from survey: discards, Manufacturing

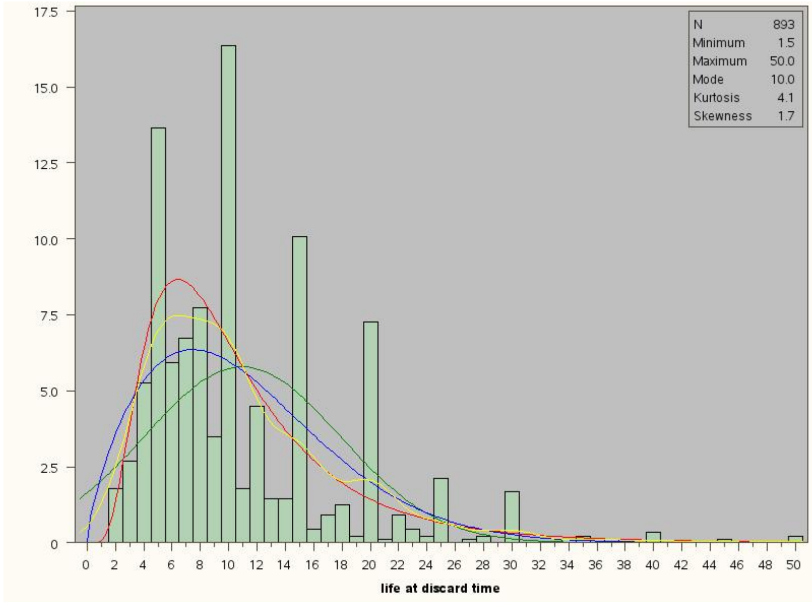


Figure 4: Retirement patterns from survey: discards, Total OM&E

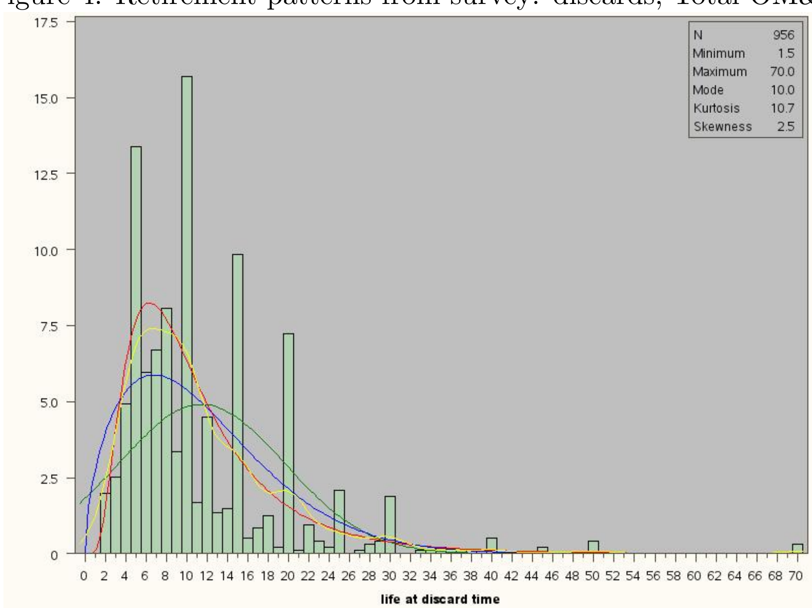


Figure 5: Retirement patterns from survey: new goods, Manufacturing

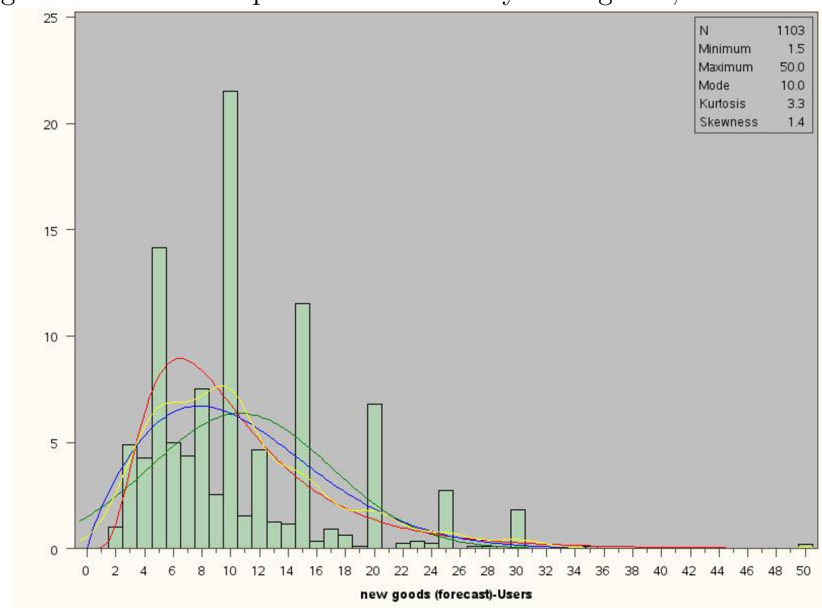
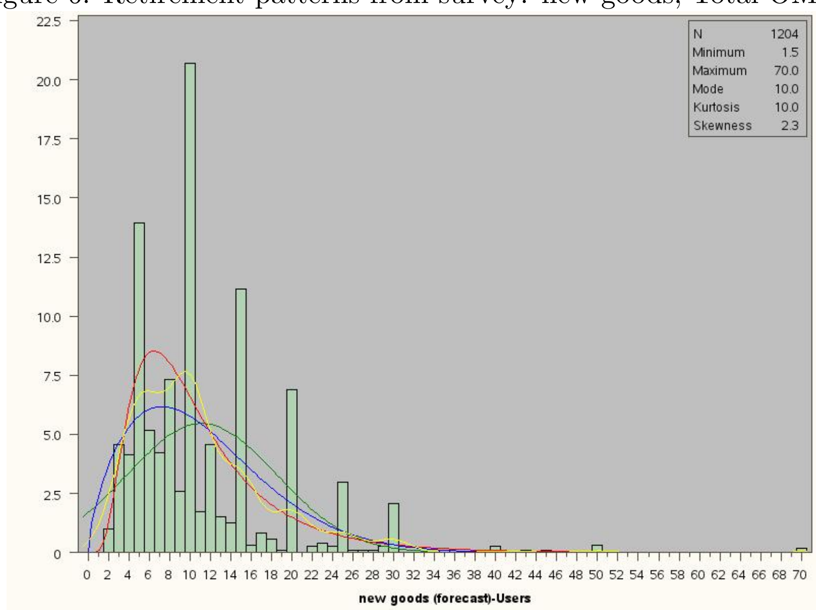


Figure 6: Retirement patterns from survey: new goods, Total OM&E



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