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Abstract

We suggest a new individual-based measure of economic insecurity where expectations about the future evolution of individual life courses are derived from a dynamic simulation model. This allows to take into account risks over many dimensions including work, family and health. On the earning side, we summarise the uncertainty over future income trajectories with a monotonically increasing concave function of income, which penalises income volatility over time and over possible individual trajectories while assigning higher value to higher levels of economic resources available. On the expenditure side, we take into account different household characteristics by means of appropriate equivalence scales.

KEYWORDS: economic insecurity, microsimulation, life course.

JEL CLASSIFICATION: C63, D63, H24, H31, I31, I32, J11, J12, J13, J18, J22, J28, J31, J62

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> I feel passionately about measurement —
> about how difficult it is,
> about how much theory and conceptualization is involved in measurement,
> and indeed, how much politics is involved.
>
> Angus Deaton, interviewed by NPR on the day his Nobel price was announced, 12 October 2015

1 Introduction

Economic insecurity has gained a centre ground in the economic and political debate in many countries. However, it still remains a more fuzzy concept than —say— inequality or poverty. This is unfortunate as economic insecurity has the potential to have great explanatory power for many individual and societal outcomes. Differently from inequality, economic insecurity is something that characterises individuals, rather than populations. It takes at least two people to talk about inequality at any given point in time, but economic insecurity can be felt even while living alone on a desert island. If people care more about themselves than about others, as commonly assumed not only in economics but also in moral philosophy, economic insecurity should be of more social concern than inequality.

As measurement is a first step towards understanding and control, having good indicators of economic insecurity is essential. In a companion paper (Richiardi and He, 2019) we surveyed some of the most prominent measures of economic insecurity put forward in the literature, from purely subjective measures (e.g. Dominitz and Manski, 1997; Green et al., 2000; Mau et al., 2012; Nau and Soener, 2019), to combined subjective and objective indicators (e.g. Rohde et al., 2015; Romaguera-de-la Cruz, 2019), to purely objective ones (Hijzen and Menyhert, 2016; Osberg and Sharpe, 2014; Hacker et al., 2014; Bossert and D'Ambrosio, 2013; Bossert et al., 2019; Rohde et al., 2014). All share a general understanding of economic insecurity as the condition of not having access to stable resources to support an adequate standard of living now and in the foreseeable future (Berton et al., 2012), which we also adopt at a conceptual level.

Apart from Osberg and Sharpe (2014) and the OECD index of economic insecurity based on Hijzen and Menyhert (2016), all the existing measures are computed at the individual level. They however differ in many other respects. Some only look at changes in the availability of individual resources (Hijzen and Menyhert, 2016; Bossert et al., 2019; Rohde et al., 2014), on the basis of the assumption that individuals feel anxious about their future if they have experienced recent losses, or if they are subject to more volatility. By converse, others (e.g. Osberg and Sharpe, 2014) are concerned with levels, and refuse to consider the billionaire that has lost half of his fortune as more insecure than the poor man that has lost the little that kept him afloat.

Most measures are computed looking only at one point in time, or possibly two points in time; amongst the surveyed measures, only Bossert and D'Ambrosio (2013), Bossert et al. (2019) and Rohde et al. (2014) consider multiple periods. Also, most indicators are normalised with respect to some reference values, either at the individual level —for instance measuring the drop in income associated to a job loss in percentage of the current income as in Hijzen and Menyhert (2016)— or at the population level —for instance standardising the indicator by the sample mean and variance as in Rohde et al. (2015). Normalisation however leads again to insensitivity to levels. In the OECD measure, a 50% expected income loss from unemployment has the same effects irrespective of the initial level of income. Standardisation in the population implies that an economic crisis that affects everyone alike has no effects on the levels of insecurity.

None of the indicators distinguishes between choices and constraints. However, it can be argued that whether individuals choose a more risky career rather than a tranquil and stable trajectory is of normative relevance. In a sense, even if many of the indexes proposed in the literature imply a strong normative judgement —insecurity is *bad*— they remain at a descriptive level of analysis.

Finally, only a few measures allow to isolate the effects of social protection (Hijzen and Menyhert, 2016; Osberg and Sharpe, 2014; Rohde et al., 2014), which is an important barrier against insecurity.

In our analysis of the literature we argued that an index of economic (in)security should ideally (i) be computed at the individual (rather than at the macro) level, (ii) be forward looking, meaning that it should consider the prospects about the future and not simply look at what happened in the past, (iii) consider both levels and changes in the availability of economic resources, (iv) consider risks over many life course dimensions, (iv) allow to identify the role of social protection, (v) be sensitive to macroeconomic conditions, meaning that if conditions worsen for everyone, insecurity should go up even if the relative position of each individual stays the same, and (vi) allow to separate at least to some extent choices from constraints.

In this paper we propose a new indicator that satisfies these requirements. Our indicator reflects a normative evaluation of individual circumstances rather than the individual perception of such circumstances, and is thus rooted in the objective approach to measuring economic insecurity. This allows interpersonal comparisons and aggregation. The indicator is described in Section 2. Its properties are analysed in Section 3, and discussed in Section 4. In order to build the indicator, a model for simulating individual life course trajectories is needed: different modelling options are discussed in Section 5. Section 6 summarises and concludes.

2 Summarising possible futures

Consistently with the requirements set forth above, we suggest to measure economic security based on a social evaluation of the expected stream of resources available to any individual over the course of his or her residual lifetime, appropriately discounted for family composition and time. More specifically, our index is

$$S_i = \frac{\int_t \int_z W(z)\delta^t f_{i,t}(z)p_{i,t}dzdt}{\int_t \delta^t p_{i,t}dt} \quad (1)$$

where $W(z_{i,t})$ is the welfare associated to the resources z available to individual i at time t, δ is the discount factor, $f_{i,t}(z)$ is the density at which resources are available and $p_{i,t}$ is the probability of being alive.

If we need to aggregate the security index, we can then proceed to a simple *cross-sectional summary* of the individual levels of security:

$$S = \frac{1}{I}\sum_{i=1}^{I} S_i. \tag{2}$$

As discussed in Richiardi and He (2019), the main indexes in the literature look at either income or wealth to measure available resources. Both variables can be used in eq. (1). However, looking at income has some advantages. First, data on income is more readily available than data on wealth, and in particular estimation of the evolution of labour income is relatively straightforward given the vast literature on structural labour supply models (Aaberge and Colombino, 2018). Second, modelling wealth requires modelling saving and consumption behaviour, increasing the level of complexity of the model. Third, controlling for capital income captures at least to some extent the effect of wealth.

Income is pooled within the household, and corrected by family characteristics (e.g. family size). This allows to consider family-related risks (and in particular risk pooling and assortative mating) on top of labour market risks. Also, by giving more weight to individuals within the household with special needs (e.g. with poor health) the index considers the expenditures side, in addition to the earnings side. By comparing market income with disposable income we are then able to disentangle the role of social protection. All sources of income should in principle be considered, including capital income. A practical problem arises here as home ownership, which for many household is the most important component of wealth, does not typically produce capital income. Conditional on data availability, this problem can be circumvented by appropriately considering imputed rents and mortgage payments. Health risks affect security indirectly through the ability to earn income.

Operationally, we suggest to use a CRRA welfare function in *equivalised real disposable household income* y:

$$W_{i,t} = y_{i,t}^{1/\alpha} \tag{3}$$

where $\alpha > 0$ is a measure of attitude to risk, with $\alpha \in (0,1)$ indicating risk propensity, $\alpha = 1$ risk neutrality and $\alpha > 1$ risk aversion.[1]

The key insight is that our welfare measure is concerned with levels, but $\alpha > 1$ penalises volatility.

[1] An interpretation of W as individual utility rather than our proposed normative evaluation of individual circumstances is certainly possible. In that case other arguments should enter the function, e.g. leisure time. A utility function could then be estimated for instance by means of a structural labour supply model, and then plugged in (3). It is not clear however why leisure time should enter the definition of insecurity. Think for instance of the case of a person who chooses a hippie way of life. She might be perfectly happy about it, but still it could be argued that she is economically insecure. Other, more practical issues arise. For instance, structural labour supply models cannot be estimated for large sub-groups of the population, for instance for students, retired people, or individuals who are forced not to work due to health conditions.

Therefore, considering this parameter does the trick of combining *levels* and *changes* on a single metric. The rationale for a concave welfare function is threefold. First, the marginal utility of consumption is decreasing, which also implies an asymmetric effects of gains and losses. Second, savings —which are typically an increasing function of income— allow to transfer utility from the current period to future periods, for which it needs further discounting. These two reasons explain why individuals might attach more weight to low income periods / state of nature than to high income ones. Third, from a social viewpoint more weight might further be attached to low incomes, due to normative considerations. Our specification captures all these motivations in a "reduced form" way, that is without specifying the contribution of each of them. Note that differently from Rohde et al. (2014) we do not interpret α as a utility parameter, but rather as a (normative) evaluation of the welfare associated to a specific level of individual income. Hence, we do not estimate α in the data, but rather leave it as a scenario parameter, possibly object of sensitivity analysis.[2]

Finally, the discount factor accounts for both a time preference and cognitive limitations to form expectations about events far into the future.

3 Properties of the S index

Some features of the S index are worth noting.

Sensitivity to levels of individual circumstances. If two distributions of individual resouces at a future time t have the same volatility but different mean, the one with higher mean is associated to higher individual security:

$$\tilde{\mu}_{i,t} > \mu_{i,t} \wedge \tilde{\sigma}_{i,t} = \sigma_{i,t} \Rightarrow \tilde{S}_i > S_i \quad \forall i, t$$

where μ and σ are respectively the mean and the standard deviation of individual resources —equivalised household income in our operationalisation as per eq. (3). This can also be understood as a *non-satiation* property: more is always better.

Sensitivity to changes in individual circumstances. If two distributions of individual resources at a future time t have the same mean but different volatility, the one with lower volatility is associated to higher individual security:

$$\tilde{\mu}_{i,t} = \mu_{i,t} \wedge \tilde{\sigma}_{i,t} < \sigma_{i,t} \Rightarrow \tilde{S}_i > S_i \quad \forall i, t$$

Second-order stochastic dominance. If one distribution of individual resources at a future

[2]This normative approach is consistent with considering a homogeneous risk aversion for all individuals (see also Capéau et al., 2019).

time t second-order stochastically dominates another, it is associated to a higher level of security:[3]

$$\int \tilde{F}_{i,t}(z)dz \leq \int F_{i,t}(z)dz \Rightarrow \tilde{S}_i > S_i \quad \forall i, t$$

Mutual independence. But for the correlation in security levels caused by a correlation in the underlying determinants, the level of security of any individual is independent of the level of security of any other individual in the population:[4]

$$F_{i,t}(z) \perp F_{j,t}(z) \Rightarrow S_i \perp S_j \quad \forall i, j, t$$

This is a direct implication of security being defined as an *absolute* level. With a relative measure, as is well known in the literature on poverty for instance, an increase in the level of security of one individual would cause a decrease in the level of security of all other individuals in the population.

Age principle. A fixed distribution of individual resources over time implies that the associated level of security is independent of residual life expectancy:

$$F_{i,t}(z) = F_i(z) \Rightarrow S_i \perp p_{i,t} \ \ \forall i, t$$

Pigou-Dalton (transfer) principle. Other things being equal (in particular, the probability of being alive), a transfer of resources in any possible future state of nature from a more secure to a less secure individual leads to an increase in the overall level of security in the population, as long as it does not leave the first individual less secure than the second.

$$\tilde{f}_{i,t}(z) = f_{i,t}(z+\Delta) \wedge \tilde{f}_{j,t}(z) = f_{j,t}(z-\Delta) \wedge p_{i,t} = p_{j,t} \wedge S_i < S_j \wedge \tilde{S}_i \leq \tilde{S}_j \Rightarrow \tilde{S} > S \quad \forall i, j, t, \Delta > 0$$

where $\Delta > 0$ is the amount of resources transferred.[5]

It should also be noted that our measure of security is likely to be pro-cyclical, as long as expectations about the availability future resources are also pro-cyclical. This is possibly the main reason to opt for an *absolute* measure of security, as we have already discussed.

Finally, it is worth considering the differences between these properties and some of the indexes proposed in the literature, in particular the axiomatic approach of Bossert and D'Ambrosio (2013); Bossert et al. (2019) and the utility-based approach by Rohde et al. (2014). The fundamental difference is that these approaches are only concerned with changes, and they distinguish between gains and losses. Levels matter in Bossert and D'Ambrosio (2013) because the higher are the

[3]Note that the property holds *a fortiori* for first-order stochastic dominance:

$$\tilde{F}_{i,t}(z) \leq F_{i,t}(z) \text{ with strict inequality at some } z \Rightarrow \tilde{S}_i > S_i \quad \forall i, t, z$$

.

[4]Family structure obviously introduces a correlation between the level of security of individual family members. Correlation between individuals who are not part of the same household would typically be induced by the macroeconomic and institutional environment, and the associated opportunities and incentives.

[5]The property also holds for the more general case $p_{i,t} \geq p_{j,t}$.

levels, the higher are also the absolute changes, generally speaking. Hence, higher access to economic resources is typically associated with higher insecurity —their very counter-intuitive Homogeneity property: if wealth in each period is multiplied by a constant λ, the corresponding level of insecurity is also increased by λ. Moreover, if losses are bad then trajectories characterised by *losses* of resources are worse than trajectories characterised by *absence* of resources —their also unappealing Resource-variation monotonicity axiom. In the example they provide, given the following five resource streams (the first element of each vector corresponds to the current period): $x_1 = (0, 0, 1, 0), x_2 = (0, 1, 0, 0), x_3 = (0, 0, 0, 0), x_4 = (0, -1, 0, 0), x_5 = (0, 0, -1, 0)$, the associated insecurity levels satisfy $V(x_1) > V(x_2) > V(x_3) > V(x_4) > V(x_5)$. x_3 —where no resources are available in any period— is associated to less insecurity than x_2, where some resources are available in some periods, because individuals are averse to losses.

In our approach on the other hand it is not trends that matter (whether increasing or decreasing), but rather the overall level of access to economic resources. One way to justify the focus on trends in these other approaches is considering that individuals might extrapolate those trends into the future. This implicit connection to the way individuals might form expectations provides the Bossert et al. and Rohde et al. approaches, which are fundamentally backward-looking, with a forward-looking narrative. On the other hand, our approach is inherently forward-looking and we model expectations explicitly. Losses are bad, in our approach, because they lower the overall level of economic resources, and gains are good because they increase it, irrespective of their sequence. Moreover, differently from all approaches in the literature with the exception of Rohde et al. (2014) we evaluate losses and gains, and more generally monetary values, under a welfare (non-linear) scale.[6]

4 Discussion

Some properties of our index appear unpleasant at first sight, but can be rationalised and contribute to shed new light on the phenomenon of economic insecurity.

To start with, the horizon of analysis is the entire residual lifetime (more precisely, the *distribution* of the residual lifetime), which obviously differs among individuals. An old individual will have his or her level of economic insecurity measured only on a few years, while evaluation for a young individual will potentially span over many decades. Moreover, uncertainty over the future is typically higher at younger ages (even considering a fixed time horizon), and young individuals have typically access to lower economic resources, at least initially. This implies that younger individuals will be on average more insecure than older ones.[7] Rather than being a problem, we consider this as a positive feature of our indicator of economic (in)security, reflecting at an intuitive level our understanding of the concept: younger individuals have lower economic resources and are more uncertain about the future, on average. They might well have more

[6] Because of the concavity of the welfare function, losses have a bigger impact on security than gains, at any level of resources. There are however no framing effects, where some reference level is considered in the evaluation.

[7] On the other hand, the Age principle ensures that if the distribution of future resources is constant over time, age does not matter.

(physical and intellectual) resources to cope with the higher level of insecurity, but this is a different story, that in our view should be measured with different indicators (for instance, with indicators of *resilience*).

Also, our definition of the welfare function W is to some extent arbitrary. This is reflected not only in the functional form chosen, but also in the risk aversion parameter α, which we keep as an exogenous parameter and do not estimate in the data. To this critique we respond in two ways. First, any concave function W would work: replacing eq. (3) with some other function would indeed be a nice robustness exercise. Second, we are clear that our measure of insecurity reflects a *normative* evaluation of individual circumstances from the point of view of society, and not an estimate of individual feelings about those circumstances. Formally, W_i is an individual contribution to a social welfare function, and not a utility function. In this respect, this is consistent with our objective approach to the measurement of economic insecurity. Individuals might differ with respect to how anxious they feel about the same life circumstances. While these differences are obviously relevant and worth consideration, it can be argued that pessimists should not be the object of more policy attention than optimists, *per se* (that is, abstracting from other implications of individual attitudes, for instance on mental health). Also, objective measures of anxiety can of course be found —for instance, looking at physical reactions like sweating, heart rate, etc., but these seem to us mostly unrelated to the measurement of economic insecurity. We wish to identify are *socio-economic conditions of objective social concern*. These depend on the prospects each individual face, and those prospects are evaluated (by the social planner) on the basis of a formal statistical simulation model, which takes into account risks on different dimensions.

Another aspect is how we consider heterogeneity in *needs*, in addition to heterogeneity in *resources*. In our measure, this is done by means of an equivalence scale that transforms household income into *equivalised* household income. This is conceptually very important as it recognises that household needs depend on household characteristics. In our definition (eq. 1) we are agnostic about how to weight household members. Simple equivalence scales typically consider only the number of household members, sometimes distinguishing between adults and children as in Hacker et al. (2014). Other individual characteristics have however a systematic and sizeable impact on needs: in particular, health conditions. We therefore suggest to adopt an equivalence scale that considers the health status of each individual household member, giving more weight to individuals with poorer health. It is also worth noting that most household characteristics have an impact on both earnings and expenditures. Poor health might lead to increased expenditures, but it might also reduce market income and increase income from social protection. The same is true for the number of dependent children, which might impact the labour supply decisions of the parents and entitle the household to child benefits and other supporting measures. By confining all the discussion about expenditures to the equivalence scale, we achieve a neat distinction between resources and needs. Our framework also allows resources and needs to be defined at the household rather than the individual level, recognising the role of risk sharing within the household and economies of scale.

This brings us to a final point. Our insistence on household income does not mean that the measure is defined only at the household level. Indeed, equivalised household income is in each period and for each state of nature attributed back to each household member, including children. Hence, the level of (in)security of the different household members will differ, because their future circumstances (hence, their future streams of equivalised household income) are different. Couples can split, and the future prospects of each partner will typically be different. Children share in any period / state of nature the income of their parents, but their future trajectories will entail leaving the parental home, at some time. This heterogeneity in the level of (in)security of different household members is in many respect a desirable property of our index, as their individual circumstances *are* heterogeneous.

5 Operationalisation

Our index could be computed on longitudinal data, allowing to assign retrospectively a level of security to each individual in each period, based on the observed evolution of their individual circumstances. Uncertainty about the future can be accounted for by appropriately aggregating individuals according to their characteristics: for each cell we then observe multiple trajectories, allowing us to compute the index in eq. (1). However, looking at longitudinal data have some drawbacks. First, most longitudinal data are relatively short.[8] Second, long surveys spanning decades inevitably suffer from attrition.[9] Third, even without attrition only "old" households can be followed for a long period of time. This implies that different versions of the security index with different time horizons need to computed for different households. Fourth, the approach would only produce a characterisation of *past* rather than *current* levels of security. Fifth, the necessity to perform the analysis at some level of aggregation in order to allow for the necessary quantification of the uncertainty around the individual trajectories undermines the same micro approach that we envisage.

As an alternative, we suggest to directly model expectations about future income streams by *simulating* individual life course trajectories, from educational choices to household composition, health status and labour market outcomes. This is not new when complete individual trajectories are needed, as for instance in the literature on lifetime inequality (e.g. Aaberge and Mogstad, 2015; Björklund, 1993; Bönke et al., 2014; Guvenen et al., 2017; Kopczuk et al., 2010; Bowlus and Robin, 2004). This literature is typically concerned with optimal choices and makes use of dynamic models where individuals engage in intertemporal optimisation over work/leisure and/or saving/consumption choices. Much of the literature on life-cycle behaviours however either abstract from possibly other relevant choices, or consider some exogenous process for (some of) them. In the list of omissions, the most glaring ones are marriage and fertility. In practice, relevant choices are omitted to maintain feasibility of solving the dynamic programming

[8]For instance, the EU Survey of Income and Living Conditions (EU-SILC) allows to follow individuals for four years only.

[9]The Panel Study of Income Dynamics in the US (PSID, running since 1968), the German Socio-Economic Panel (GSOEP, established in 1984) and the Household, Income and Labour Dynamics in Australia (HILDA, started in 2001). The British Household Panel Survey (BHPS), combined with its successor UKHLS, allows to follow a first sample of households since 1991.

problem and the simplicity to understand the underlying mechanism through which a policy change affects behaviours. However, whether the omission leads to a biased implication of the effect of tax and benefit policies is an open question. For example, Haan et al. (2018) study how the tax-and-transfer system reduces the inequality of lifetime income based on a life-cycle model of consumption, saving and labour supply, taking education as given (although education affects choices and opportunity sets) and ignoring marriage and fertility. Low et al. (2010) have a life-cycle model for males where individuals choose consumption, whether to work, whether to change job if the opportunity arises, and how much to save, taking education as given. Even if one can assume that male preferences are separable from marriage and fertility as often done in the literature on male labour supply, marriage and fertility choices may well change in response to welfare reforms and bias the evaluation of welfare programs which is the focus of their paper. Blundell et al. (2016) study how tax credits targeted to low-income families with children affect the careers of women. In their specification, at the start of the life-cycle, women choose between three possible education levels (secondary, high school, and university). Once education is completed, they make period-by-period employment and savings decisions depending on wages, preferences, and family structure, which evolves over the life-cycle. While male income, fertility, and marriage are exogenous, they are driven by stochastic processes that depend on education and age. Like Low et al. (2010), the family formation and fertility are not allowed to change as a result of welfare reform which is a limitation of the paper.

An alternative to dynamic programming models is dynamic microsimulation (Li and O'Donoghue, 2013). This is a modelling approach where a rich set of individual and characteristics are allowed to evolve over time, each potentially affected by policies. Households are therefore endogenously formed, evolved and eventually destroyed. Demographic and socio-economic variables are assumed to follow a Markov process. Estimation typically involves a conditional independence assumption, where all transitions are separately estimated after controlling for individual and household characteristics at the moment of the transition, including lagged states. This is similar to the literature on multistate models and Markov models in Sociology (e.g. Schoen and Nau, 2009), with the difference that microsimulation models are typically used for out-of-sample prediction. Various degree of sophistication can guide the specification of the different processes, from simple discrete choice and regression models to more complicated models where the role of unobserved heterogeneity is considered, as in Richiardi and Poggi (2014). The absence of intertemporal optimisation is often considered as a litmus test to distinguish dynamic microsimulation from dynamic programming models. The justification for abstracting from intertemporal considerations in dynamic microsimulations is twofold. From an empirical perspective, it can be argued that in real life individuals are often constrained in their ability to optimise over the life cycle. From a modelling perspective, there is a trade-off between complexity in behaviour and richness in the characterisation of individual heterogeneity, and microsimulation models generally favour the latter: these modelling exercises are generally more interested in understanding the combined effects of the different trends estimated in the data —e.g. in education, family and work fragmentation, female labour force participation, fertility, etc.— than in understanding the nuances of behavioural responses to policy changes. However, exceptions exist. For instance, van de Ven (2017a,b) considers life cycle optimisation over savings and employment choices. He includes separate processes for wages, household formation and dissolution, fertility, education, health, caring responsibilities, migration, and time of death, thus going a long way in the direction of the dynamic programming approaches described above.

What is important is not the specific model used, but rather the idea of simulating individual trajectories, from the time individuals are observed in the data until retirement, emigration or death. With an open population architecture we can go even further and simulate the life course of future individuals who will enter the simulation as a consequence of fertility choices or immigration, and also model intergenerational transfers.[10] Moreover, both dynamic programming and dynamic microsimulation are behavioural approaches, even if the extent and the sophistication of the behavioural responses vary. This feature allows building counterfactuals for evaluating policies. Depending on the specification, relying on a model of individual behaviour might also allow to distinguish between choices and constraints.

There is one more feature of simulation models that can be usefully exploited for measuring economic insecurity. Typically, simulation models are run in order to produce one synthetic panel, on which analysis is performed. Occasionally the models are run multiple times and then the results averaged in order to iron out Monte Carlo variation (the fact that some events in a simulation model are stochastic and depend on the specific seed of the random number generator that controls the randomness in the model). However, the focus on economic insecurity implies that this Monte Carlo variation is of interest in itself. We can therefore simulate individual trajectories multiple times and —rather than look at the mean individual outcomes— reconstruct entire distributions of individual trajectories, fully characterising the associated uncertainty. The security index computed on simulated data then takes the form

$$S_i = \frac{1}{R} \sum_{r=1}^{R} \left(\frac{\sum_{t=0}^{T_r} y_{i,t,r}^{1/\alpha} \delta^t}{\sum_{t=0}^{T_r} \delta^t} \right) \tag{4}$$

where R is the number of different runs of the model (each characterised by a different seed of the random number generator that controls the randomness in the model), T_r is the residual lifetime of individual i in the r trajectory (which is itself simulated) and $\delta \in (0, 1]$ is the constant discount factor. This is nothing else than a weighted average of the welfare associated to future possible income streams, with weights equal, in every period, to δ^t.

6 Conclusions

Our suggestion is to complement the battery of indicators available to researchers in this area with a new measure that extends the time horizon considered to the future, hence requiring an explicit modelling of expectations. Our time frame potentially includes all the residual lifetime of each individual, although discounting implies an exponential decay in the contribution of

[10] Obviously, the accuracy of the simulation will diminish over time. See Richardson et al. (2018) for an example of uncertainty analysis within a dynamic microsimulation setting.

periods which lay further ahead. To take into account the multidimensionality of life course trajectories, we suggest to model expectations based on simulations of individual trajectories. If the simulation model is rich enough, it allows to separately identify the contribution of many different hazards —from labour market risks to family and health risks— and barriers against insecurity (in particular the role of social protection).

We also propose to generalise and simplify the consideration of what is considered "good" and what is considered "bad" with a unique and monotonically increasing monetary metric, so that *ceteris paribus* higher access to economic resources is always considered "good", i.e. security-increasing.

It is our hope and belief that our index will provide a useful tool to complement the existing indicators, and further push forward the research on economic insecurity.

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