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A Reconsideration of Microeconomic Foundations of Macroeconomics [1]

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Abstract

Macroeconomics and microeconomics are fundamentally different. In microeconomics such as industrial organization and market for "lemon", detailed analysis of motives and strategic behavior of micro-agents is necessary. However, in macroeconomics, such analysis is of no use. To understand macroeconomic phenomena, different methodologies are required. Research programs related to the standard microeconomic foundations of macroeconomics are on the wrong track. Taking RBC, Lucas rational expectations model, labor search theory, and the more recent HANK as examples, this paper shows that the standard microeconomic foundations of macroeconomics rest essentially on unrealistic representative agent assumptions and are not worthy of being called microeconomic foundations. It reconsiders Keynesian economics as an indispensable framework for the analysis of business cycles and argues for a stochastic approach in understanding important macroeconomic phenomena such as distributions of personal incomes and firm growth.

Keywords: Keynesian, Neoclassical, Business Fluctuations, Gibrat's law
JEL classification: E12, E13, E32, E62

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1. Introduction

During the 1950's and 60's, what Paul Samuelson called *neoclassical synthesis* regarded economics as dual. Namely, it consists of two pillars, neoclassical microeconomic theory which analyzes efficient resource allocation under the state of "full employment," and Keynesian economics which analyzes the economy with unemployment. Macroeconomics was synonymous with Keynesian economics. In those days, neoclassical synthesis was widely accepted by the academic community. All over the world, economics was taught, and textbooks were written that way.

However, during the late 1960's, the neoclassical synthesis of micro/macroeconomics was gradually eroded, and for the last fifty years, macroeconomics has turned into neoclassical theory. The claim is that Keynesian economics is devoid of microeconomic foundations, and that correct macroeconomics must have rigorous microeconomic foundations. The volume edited by Phelps (1970) entitled *Microeconomic Foundations of Employment and Inflation Theory* had a decisive influence on macroeconomics. Subsequently, the "rational expectations revolution" of Lucas (1972, 73) and the real business cycle theory (RBC) of Kydland and Prescott (1982) literally transformed macroeconomics. It suffices to cite Lucas' (1987) "Declaration of Victory" as representative of the trends in the academic world.

> The most interesting recent developments in macroeconomic theory seem to me describable as the reincorporation of aggregative problems such as inflation and the business cycle within the general framework of 'microeconomic' theory. If these developments succeed, the term 'macroeconomic' will simply disappear from use and the modifier 'micro' will become superfluous. We will simply speak, as did Smith, Ricardo, Marshall and Walras, of economic theory. If we are honest, we will have to face the fact that at any given time there will be phenomena that are well-understood from the point of view of the economic theory we have, and other phenomena that are not. We will be tempted, I am sure, to relieve the discomfort induced by discrepancies between theory and facts by saying that the ill-understood facts are the province of some other, different kind of economic theory. Keynesian 'macroeconomics' was, I think, a surrender (under great duress) to this temptation (Lucas 1987, 107-108).

As Lucas suggests, since the 1980s, macroeconomics has been transformed into micro-founded macroeconomics with micro-optimization at its core.

However, economics must be dual consisting of two pillars, macroeconomics and microeconomics. The reason is that there are two different problems in the economy. On one hand, we have micro problems such as industrial organization and market for "lemon", and on the other, macro problems such as business cycles. The essential difference between the two is that in the former, namely in microeconomics, we must explore economic motives and strategic behavior of consumer and firm, whereas in macroeconomics, detailed analysis of micro behavior is of no use. Microeconomics and macroeconomics are fundamentally different.

From this standpoint, section 2 explains that standard micro-foundations are on the wrong track. The fundamental problem is that we can never observe optimization of micro economic agent. For the purpose of introducing such unobservable micro optimization into model, modern micro-founded macroeconomics must rest necessarily on representative agent assumptions. In the case of real business cycle (RBC) theory and endogenous growth theory, this is obvious, for literally single representative household/firm is assumed. In contract, in the case of Lucas' rational expectations model, labor search theory, and more recent mean field game and dynamic stochastic general equilibrium (DSGE) model, the problem is much subtler because in these models, apparently heterogenous agents are assumed. However, economic agents differ only to the extent that realization of relevant stochastic variable is different. They are assumed to face a common stochastic distribution with which they optimize. We contend that the assumption that all the economic agents share a common stochastic environment, namely the assumption of representative constraints is wrong. It is essentially nothing but stochastic version of representative agent assumption, not worthy of micro-foundations.

Business cycle is the alpha and omega for macroeconomics. Section 3 argues for old Keynesian economics in which the principle of effective demand plays the central role. There are other important macro-phenomena such as distributions of personal incomes and firm size. For the purpose of explaining such phenomena, detailed analysis of micro-behavior is no use. Section 4 explains stochastic approach. Section 5 offers brief concluding remarks.

2. Standard Micro-foundations are False

Before we discuss micro-foundations of macroeconomics, it would be useful to define what macroeconomics is meant to be. Macroeconomics is supposed to explain changes of *macro* variables by changes of some other *macro* variables. Such macro variables are, of course, observable though most of them are compiled by government. Keynesian economics or what Tobin called the Old Keynesian view according to which aggregate demand determines aggregate production, is a typical example. Modern economists claim that Keynesian economics lacks rigorous micro-foundations; namely optimization of micro economic agents such as household and firm is not explicitly considered in model.

RBC

A prototype of micro-founded macroeconomics is real business cycle (RBC) models originated by Kydland and Prescott (1982).[1] RBC is now the basic framework of standard macroeconomics. In the model, the representative Ramsey-type consumer maximizes intertemporal utility under the constraint on production which is subject to stochastic productivity shocks. Here, *macro* productivity

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[1] The first micro-foundaed macro model is arguably Uzawa (1969).

shocks produce fluctuations of *aggregate* production or GDP. In this macro model, optimization of consumer is explicitly analyzed. Thus, the model is micro-founded.

The problem is the assumption of representative consumer. It is certainly a big embarrassment to hold that the macroeconomy is characterized by behavior of a single representative consumer because we know that consumers and firms all differ in many respects. A well-known criticism is Kirman (1992) entitled "Whom or what does the representative individual represent?" Solow (2004) is another. The same problem applies to most models of endogenous growth which assume representative agents.

Kiyotaki (2011) argues, however, that despite of apparent set up of basic models, RBC actually does not rest on the assumption of representative consumer/firm.

> Note that the representative household is not an assumption; it arises as an implication of constant Negishi weights under complete markets as in Negishi (1960). The aggregate production function is also constructed under the assumption that production is efficient in competitive markets without friction. Therefore, the real business cycle theory does not blindly abstract from firm and household heterogeneity. By assuming that markets are functioning "well," we reduce an otherwise general model to one of the representative agent with an aggregate production function and analyze the business cycle phenomenon in this simplified economy (Kiyotaki, 2011, 197).

Negishi (1960) shows that the general equilibrium of the economy consisting of many heterogeneous consumers and firms is equivalent to the outcome of maximization of utility by the single representative consumer. In other words, Negishi proves the existence of a unique social welfare function maximization of which coincides with the Walrasian general equilibrium (GE). Drawing on this result, Kiyotaki argues that criticizing RBC for apparent representative agent assumptions is beside the mark.

First, Negishi assumes complete markets. Presence of any kind of market failures negates his results. Therefore, well-cited Kiyotaki/Moore (1997) which assumes representative consumer in the economy with market imperfection cannot legitimately draw on Negishi for justifying representative agent assumptions.

Kydland/Prescott (1982) RBC is based on complete markets, and therefore, the Negishi proposition applies. However, what makes RBC a *macro* model is not the Negishi proposition, but very restrictive assumptions on utility and production functions. After all, RBC assures that utility and production functions are the same for all the consumers and firms in GE. This assumption ensures that positive (negative) *aggregate* productivity shocks raise (lower) *aggregate* production or GDP. It is very important to recognize that what Negishi (1960) shows is the existence of social welfare function in Walrasian GE. This result does not by itself lead us to any prediction for a particular direction of change of *macro* variables in response to a change of certain *macro* variable in the economy.

The problem has been long recognized in the field of traditional Walrasian GE. Beginning with Sonnenschein (1972), theorists such as Debreu (1974), Hildenbrand (1983), and Jerison (1999) have shown that the "law of demand" —— macro relationship —— does not ensue merely from standard assumptions in GE. Ambiguity arises from income effects when price changes. To obtain the macro "law of demand" equivalent to negative definiteness of the Jacobian matrix of price derivatives of mean demand, we must make additional restrictive assumptions such as the identical consumer preferences. Härdle, Hildenbrand and Jerison (1991; p.1525) state as follows:

> When general equilibrium models are used to make comparative static predictions they cease to be general. This is necessarily so. Without a specific structure of the demand and supply system one cannot expect any definite comparative static results. However, in most analyses, conclusions depend upon structure imposed either by aggregating consumers into a single representative, or by assuming restrictive forms for utility or production functions. Such analyses therefore deal with special cases. ・・・・・・
>
> The Law of Demand concerns effects of price changes when households' budgets (total expenditures) are fixed. It is a condition referring to a counterfactual, asking how mean demand would differ if prices were different. As such it cannot generally be tested using time series data. If the observation period were long enough to reveal significant price variation, it would probably also show changes in households' budgets, preferences, and demographic characteristics. (Härdle, Hildenbrand and Jerison (1991; p.1525).

Their remarks caution that the problem is particularly difficult for macroeconomics which deals with changes over time because micro environments facing individual consumers and firms keep changing over time.

The Negishi proposition concerns the well-known fundamental theorem of welfare economics, and by itself has nothing to do with what makes RBC a workable *macro* model. RBC and endogenous growth models rely crucially on representative agent assumptions. After all, we can judge by their appearances!

Lucas/Sargent Rational Expectations Models

Lucas/Sargent Rational Expectations (RE) models are different from RBC in that consumers and producers have different utility and production functions. On the surface, there is no representative economic agent. However, all the micro economic agents are assumed to share the same stochastic *macro* model as the constraint under which they optimize. This assumption of *representative stochastic constraints* makes RE models a workable macro model; Unanticipated changes of money stock produce fluctuations of aggregate production or GDP. The model is nothing but a stochastic version of representative agent model.

This theoretical framework was first introduced by Phelps (1970). He uses a famous model of "islands" in which symmetric economic agents face the identical distribution of stochastic variables. The Lucas RE is just an example. As Aoki and Yoshikawa (2007) explain, it essentially corresponds to Markov model with symmetric one-level tree of the transition probability (Figure 1(a)).

(a) (b)

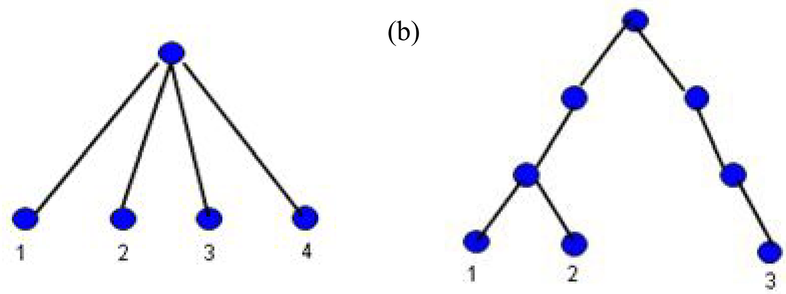


Figure. 1: Tree of the transition probability of the Markov model
The figures are taken from Yoshikawa (2022).

However, in reality, firms' economic environment or constraints under which they optimize are not symmetric, but all differ. In terms of Markov model, transition rates are not symmetric one-level tree, but multi-level tree (Figure 1(b)).

Labor Search Theory

Search theory starts with the presence of various frictions and accompanying matching costs in market transactions. Once we recognize these problems, we are led to heterogeneity of economic agents and multiple outcomes in equilibrium. In search equilibrium, potentially similar workers and firms experience different economic outcomes. For example, some workers are employed, while others are unemployed, although they are practically similar workers. In this way, search theory well recognizes and even emphasizes the heterogeneity of workers and firms.

Despite this recognition, in regard to modeling the behavior of economic agents such as workers and firms, standard search theory makes untenable assumptions. First, in the name of Poisson productivity shocks, it presumes perfect competition, namely horizontal individual demand curve in product market. It is plainly against the sprit of search theory. In what follows, we focus on labor market.

The standard model, in effect, presumes the representative agent in the sense that a stochastic economic environment is common to all agents; Workers and firms differ only in terms of the realizations of stochastic variables of interest whose probability distribution is common. Specifically, it is routinely assumed that the job arrival rate, the job separation rate, and probability distributions of wages and productivity are common to all workers and firms. In some models, such as Burdett and Mortensen (1998), the arrival rate is assumed to depend on a worker's current state, namely, either employed or unemployed. However, within each group, the job arrival rate is common to all workers. Like Lucas' RE model, search model is essentially Phelps' island model.

The job separation includes layoffs as well as voluntary quits. It makes no sense that all firms and workers face the same job separation rate, particularly the probability of layoffs. White collar and blue collar workers face different risks of layoff. Everybody knows the difference between new expanding industry and old declining industry. In any case, the probability of layoffs depends crucially on the state of demand for the firm's product and, as a result, among other things, on industry, region, and ultimately the firm's performance in the product market. Thus, the probability is far from being common to all firms and workers but is *firm-specific* and *worker specific*.

We can always calculate the average job arrival rate and job separation rate, of course. However, the average job arrival rate and the economy-wide wage distribution, which, by definition, determine the average duration of an unemployment spell, would be relevant only to decisions made by policy makers such as the ministry of labor. *When individual private economic agents make decisions, they are not relevant because the job arrival rate, the job separation rate, and the wage distribution facing individual workers and firms are all different*.

As a macro description, equations routinely assumed in the literature are innocuous. However, when linked to the optimization of micro agents, the standard equation in the literature, in effect, presumes that the offer arrival rate, the reservation wage, and the cumulative distribution function of wage offers are common to all workers. In reality, they differ significantly across workers. However, in standard search models, the common distribution of wage offers is put into the Bellman equations describing the behaviors of firms and workers. Furthermore, workers care not only about wages but also about other factors such as job quality, tenure, and location. They are so diverse that the third party can never observe them.

The problem is actually partly recognized by search theorists themselves. The recognition has led them to introduce the "matching function" into the analysis. The matching function relates the rate of meetings of job seekers and firms to the numbers of the unemployed and job vacancies. The idea behind it is explained by Pissarides (2011) as follows.

> Although there were many attempts to derive an equilibrium wage distribution for markets with search frictions, I took a different approach to labor market equilibrium that could be better described by the term "matching". The idea is that the job search underlying unemployment in the official definitions is not about looking for a good wage, but about looking for a good job match. Moreover, it is not only the worker who is concerned to find a good match, with the firm passively prepared to hire anyone who accepts its wage offer, but the firm is also as concerned with locating a good match before hiring someone.
>
> The foundation for this idea is that each worker has many distinct features, which make her suitable for different kinds of jobs. Job requirements vary across firms too, and employers are not indifferent about the type of worker that they hire, whatever the wage. The process of matching workers to jobs takes time, irrespective of the wage offered by each job. A process whereby both workers and firms search for each other and jointly either accept or reject the match seemed to be closer to reality.
>
> …… It allowed one to study equilibrium models that could incorporate real-world features like differences across workers and jobs, and differences in the institutional structure of labor markets.

> The step from a theory of search based on the acceptance of a wage offer to one based on a good match is small but has far-reaching implications for the modeling of the labor market. The reason is that in the case of searching for a good match we can bring in the matching function as a description of the choices available to the worker. The matching function captures many features of frictions in labor markets that are not made explicit. It is a black box, as Barbara Petrongolo and I called it in our 2001 survey, in the same sense that the production function is a black box of technology (Pissarides 2011, 1093-1094).

What a job seeker is looking for is not simply a good wage but a good job offer that cannot be uniquely defined but differs significantly across workers. True heterogeneity is simply unspecifiable. Pissarides recognizes such "real-world features" as differences across workers and jobs; the "universe" differs across workers and firms. Then, at the same time, he advances the idea of a macro black box. The matching function is certainly a black box not explicitly derived from micro optimization exercises and is, in fact, not a function of any economic variable that directly affects the decisions of individual workers and firms.

Good in spirit, but the matching function is still only a half way. It is based on a kind of common sense in that the number of job matches increases when there are a greater number of both job seekers and vacancies. However, it still abstracts itself from an important aspect of reality. As Okun (1973) emphasizes, the problem of unemployment cannot be reduced only to numbers.

> The evidence presented above confirms that a high-pressure economy generates not only more jobs than does a slack economy, but also a different pattern of employment. It suggests that, in a weak labor market, a poor job is often the best job available, superior at least to the alternative of no job. A high-pressure economy provides people with a chance to climb ladders to better jobs.
>
> The industry shifts are only one dimension of ladder climbing. Increased upward movements within firms and within industries, and greater geographical flows from lower-income to higher-income regions, are also likely to be significant (Okun 1973, 234-235).

Unemployment cannot be separated from the qualities of jobs. The aggregate matching function is based on the recognition that matchings of workers and jobs are so diverse that they cannot be described by micro optimization. However, it still abstracts itself from true homogeneity of workers and jobs. In considering the problems Pissarides (2011) raised, we face greater complexity and, therefore, need a "greater macro black box" than the standard matching function.

Standard Mortensen/Pissarides labor search models consider apparently heterogeneous economic agents such as the employed and unemployed workers. However, they share the same stochastic macro distributions with which they optimize. Thus, models are nothing but a stochastic version of representative agent models. The matching function is motivated by heterogeneity in labor market, but still fails to capture true heterogeneity. Yoshikawa (2015,2022) demonstrates that the aggregate matching function is actually not a structurally given function or technology, but depends crucially on the level of aggregate demand. This analysis provides us with correct micro-foundation of Keynesian economics as we discuss in section 3.

New Keynesian Dynamic Stochastic General Equilibrium (DSGE) Model

DSGE is a broad concept. By definition, RBC is a kind of DSGE. Here, we discuss a branch of DSGE which a group of economists call new Keynesian model. Gali (2018) makes the following claim:

> In August 2007, when the first signs emerged of what would come to be the most damaging global financial crisis since the Great Depression, the New Keynesian paradigm was dominant in macroeconomics. It was taught in economics programs all over the world as the framework of reference for understanding fluctuations in economic activity and inflation and their relation to monetary and fiscal policies. It was widely adopted by researchers as a baseline model that could be used flexibly to analyze a variety of macroeconomic phenomena. The New Keynesian model was also at the core of the medium-scale, dynamic stochastic general equilibrium (DSGE) models developed and used by central banks and policy institutions throughout the world (Gali (2018), p.87).

The framework is based on standard optimization of households and firms solved under the assumption of rational expectations, but unlike RBC, introduces nominal rigidities of prices and wages. Thus, it is not neoclassical economics, but allegedly Keynesian.

The first generation of new Keynesian model is representative agent model. Therefore, criticism of RBC applies to it. To the extent that such model is used for guiding monetary policy, the serious problem arises. Namely, as Kaplan, Moll and Violante (2018) show, in representative agent model, transmission from changes in interest rates to consumption is driven by intertemporal substitution of represent consumer. This is not borne out by well-known fact that the direct impact of changes in interest rates on consumption/saving is small. This problem motivates economists to introduce *heterogeneous* economic agents into DSGE. Such model is now called heterogenous agent new Keynesian model (HANK) as compared to representative agent new Keynesian model (RANK).

Does HANK such as Kaplan, Moll, and Violante (2018) succeed in introducing heterogenous economic agents? Their paper is entitled “Monetary Policy according to HANK.” Does it provide us with useful guidance on monetary policy? Unfortunately, the answer is no.

Certainly, the direct impact of changes in interest rates on consumption/saving is small. Plainly, RANK which relies overwhelmingly on intertemporal substitution of representative consumer for the transmission mechanism of monetary policy cannot stand use. This motivates Kaplan, Moll and Violante to introduce heterogeneous agents into new Keynesian model. However, in their model, consumers are “heterogenous” to the extent that they face “idiosyncratic labor productivity shocks” which are assumed to cancel out leaving market wage unaffected.

Production of final goods is done by a competitive representative firm using a continuum of intermediate inputs. Producers of intermediate goods are monopolistically competitive. Because they are symmetric, cost minimization implies that the marginal cost is common across all producers. This analysis leads us to the New Keynesian Phillips curve. Monetary policy concerns price or inflation, of course. Their Phillips curve depends wholly on representative firm assumption, not heterogeneous agents at all. Household's income depends on wage income. Now, labor is demanded by symmetric firm, again not heterogenous agent at all. On the contrary to the authors' claim, the model is essentially representative agent model, not worthy of heterogeneous agent model.

In such a model, they consider the effects of a change in the short-term nominal interest rate. Such an exercise misses an essential part of monetary policy because interest rate is not all that matters. The point is made by Tobin (1978) in plain words:

> Many businesses, like many households, are liquidity-constrained. The pace of their real investment, whether in working capital or fixed capital, is limited by their cash flow and the credit they can obtain. ……
>
> A "credit crunch" is not just a time of high and rising interest rates. It is a time when some business customers of commercial banks find that they cannot fully use the credit lines they thought they had, that they cannot obtain the timely accommodation they presumably had paid for by good deposit behavior in the past. They are liquidity-constrained all of a sudden, in the sense that they need credit to carry out their investment and financial budgets. ……
>
> Just as the prevalence of liquidity-constrained unsatisfied borrowers in booms augments the power of tight money and credit crunches, so the relative absence of such borrowers in depressions and deep recessions weakens expansionary monetary policy. (Tobin (1978), pp.428-429)

The extent of indebtedness, bad assets and resultant "credit crunch" facing individual households and firms, we never know. That's true heterogeneity. HANK hardly captures such heterogeneity which plays crucial role in the transmission mechanism of monetary policy.

In passing, using micro panel data, Kuchler and Zafar (2019) report an interesting finding that expectations on *macro* variables such as housing prices and unemployment held by individual consumers depend strongly on their idiosyncratic past experiences. Such subjective expectations affect economic decisions of individual consumers, not observable regional housing price nor unemployment. The point is that even observed macro variables are *not* commonly shared by individual consumers so long as they affect economic decisions. Some economists, perhaps including Kuchler and Zafar themselves might argue that we can group consumers by personal experiences. However, age, unemployment, and mortgage, for example, are only the tip of the iceberg, and the list of personal experiences is endless. If one exhausted such lists for all the consumers, what is left of macroeconomics? Simply, because we, economists cannot observe personal experiences, we never observe micro behavior. This is the reason why we regularly obtain very low R squared in micro regression which necessarily uses observables as explanatory variables.

3. Keynesian Economics

Micro-founded macroeconomic models critically reviewed above are all neoclassical. Contrary to their claims, alleged micro-foundations are false. In this section, we argue for Keynesian economics, not new but old.

Prior to the details of model specifications, the most important point for any macro model is the choice of exogenous and endogenous variables. Standard neoclassical theory takes technology, preferences, and factor endowments as exogenous. Keynes presented the vision that cyclical changes in aggregate economic activity, namely, quarter-to-quarter or year-to-year changes in real GDP, are basically determined by changes in *real* aggregate demand. This is the central message of Keynes (1936).

The fundamental reason why *aggregate demand* becomes the most important determinant of macroeconomic activity in the short run is that aggregate demand can change swiftly, whereas factor endowment and technology change only slowly.

> The central Keynesian proposition is not nominal price rigidity but the principle of effective demand (Keynes, 1936, Ch. 3). In the absence of instantaneous and complete market clearing, output and employment are frequently constrained by aggregate demand. In these excess-supply regimes, agents' demands are limited by their inability to sell as much as they would like at prevailing prices. Any failure of price adjustments to keep markets cleared opens the door for quantities to determine quantities, for example real national income to determine consumption demand, as described in Keynes' multiplier calculus. …
> In Keynesian business cycle theory, the shocks generating fluctuations are generally shifts in real aggregate demand for goods and services, notably in capital investment (Tobin, 1993, 46-47).

Tobin dubbed his own position an "Old Keynesian view". Certainly, the main message of Keynes (1936) is that real demand rather than factor endowment and technology determines the level of aggregate production in the short run simply because the rate of utilization of production factors such as labor and capital endogenously change in response to changes in real demand. Keynes maintained that this proposition holds true regardless of flexibility of prices and wages; he, in fact, argued that a fall of prices or wages would aggravate, not alleviate the problems facing the economy in deep recession because it may actually lower aggregate demand.

Following Tobin, let us call this proposition the Old Keynesian view. According to the Old Keynesian view, changes in real aggregate demand for goods and services generate fluctuations of output. The challenge is then to clarify the market mechanism by which aggregate demand conditions the allocation of production factors in such a way that total output follows changes in real aggregate demand. A decrease in aggregate output is necessarily accompanied by a lower utilization of production factors, and vice versa.

Yoshikawa (2015, 2022, Ch.3) presents micro-foundations for Keynesian economics based on the methods of statistical physics. It is extremely important to recognize that this approach does not regard the behaviors of workers and firms as random. They certainly maximize their objective functions perhaps dynamically in their respective stochastic environments. Of course, as behavioral economics has demonstrated, real optimization may be different from utility/profit maximization, as traditional economics takes as an axiom. However, that is not a crucial point any way for the purpose of macroeconomics.

The maximization of Shannon's entropy under the aggregate demand constraint balances two forces. On the one hand, whenever possible, workers are assumed to move to better jobs that are identified with job sites with higher productivity. We never know which jobs are how attractive to which workers. Firms make efforts to hire good workers under demand constraints in the goods market. Again, we never know which workers are how good to which firms. It is the outcome of successful job matching resulting from the worker's search and the firm's recruitment. When the level of aggregate demand is high, this force dominates because the demand for labor of high productivity firms is high.

However, as the aggregate demand decreases, the number of possible allocations consistent with the level of aggregate demand increases. More workers are forced to be satisfied with or look for low-productivity jobs. Randomness, which plays a crucial role in our analysis, basically comes from the fact that demand constraints in the product market facing firms with different productivity and optimizing behaviors of workers and firms under such constraints are so complex and unspecifiable that those of us who analyze the macroeconomy must take micro behaviors as random. The method is straightforward and does not require any arbitrary assumptions on the behavior of economic agents.

When the level of aggregate demand is high, it is most likely that high productivity firms keep more workers on the job and make more aggressive hiring efforts than in the period of low demand. Workers are certainly aware of such a change. It is demonstrated by the fact that quit rates are higher in high-demand periods although the employed workers are treated better in such periods. Whether better jobs are truly offered and workers move to those jobs ultimately depends on the level of aggregate demand. Our analysis demonstrates that the most likely outcome of random matching of firms and workers depends on aggregate demand. It broadly coincides with the empirically observed distribution of productivity.

We emphasize that frictions and uncertainty in the labor market are not exogenously given but depend crucially on the aggregate demand. There is no such thing as the natural unemployment defined by Friedman (1968) because the aggregate demand fundamentally conditions the rate of successful matching. We must also note that the role of reservation job attractiveness also depends crucially on aggregate demand. It is shown that in a deep recession, reservation job attractiveness (or wages) plays only a relatively small role as a determinant of unemployment.

To repeat, the level of aggregate demand is the ultimate factor conditioning the outcome of random matching of workers and monopolistically competitive firms. By so doing, it changes not only unemployment but also the distribution of productivity and, as a consequence, the level of aggregate output. This is the market mechanism beneath Keynes' principle of effective demand.

Contrary to many economists' beliefs, the old principle of effective demand has a solid micro-foundation. The market mechanism beneath Keynes' principle of effective demand is the general equilibrium of monopolistic competition coupled with search by workers and firms under friction and uncertainty. It is a cliché that the Keynesian problem of unemployment arises because prices and wages are inflexible. Tobin (1993), in fact, Keynes (1936) himself argued that the principle of effective demand holds true regardless of flexibility of prices and wages. This is because real demand changes much more swiftly than technology, and adjustment in terms of quantity is faster than that by way of changes in prices. Keynesian economics, in effect, claims that in the short run, aggregate demand conditions the matching of workers and firms and thereby determines the utilization of labor and the level of output in the macroeconomy. The logic does not depend on details of economic agents' micro behavior. We maintain that this is correct microeconomic foundation for macroeconomics.

4. Stochastic Approach

We obtain distributions of many economic variables. Such distribution provides us with important information for our understanding the macroeconomy.

Distribution of Personal Income

An important example is distribution of personal income. Pareto (1896) found that in many countries the distribution of income, especially for the upper-income group, follows power laws. It is now known that the power distribution is found universally in many natural phenomena such as earthquake and flood, but one found by Pareto is believed to be the oldest in the history of the discovery of empirical power distribution. For this reason, Pareto is perhaps the most widely known economist today among physicists who are interested in econophysics and power distribution; Pareto is famous only because of the "Pareto distribution", and no physicist knows the concept of the Pareto optimum!

The distribution of personal income is, of course, a macro relation. The question is then how to interpret such a macro relation, or to link micro behavior. Champernowne (1953, 1973) tutored by Keynes as student at Cambridge purposefully gave up pursuing details of micro behavior, and instead resorted to stochastic approach. Specifically, he considered the following multiplicative stochastic process, for income Y:

$$Y_{t+1} = r_{t+1} Y_t \tag{1}$$

r is a growth factor (growth rate plus 1). If r is greater than 1, income Y rises, and conversely, if r is less than 1, Y falls. r is a random variable with identical and independent distribution. The density function

$f(r)$ ($r \geq 0$) does not depend on the level of Y. In other words, the "growth rate" follows the same probability distribution regardless of the level of income. This assumption plays an essential role in obtaining the power distribution.

The income distribution (Pareto distribution) of a country is a macro phenomenon. Behind the macroscopically stable income distribution, individual incomes are constantly changing. The factors that determine such fluctuations are, as we have repeatedly remarked, too complex and can only be described as random in the eyes of a third-party analyst. The only valid model is a stochastic model. The income distribution as a macroscopic phenomenon must be explained as stochastic equilibrium. This is what Champernowne thought. Note that probability density function $f(r)$ above is macro function which the third party, economist uses for the purpose of his/her analysis. However, it has nothing to do with stochastic environment pertaining to personal income of each individual.

Resorting to stochastic approach, Champernowne could successfully explore the structure of stochastic process which leads to empirically observed power distribution for high incomes. The finding has tremendous relevance to today's global problem of inequality. It is extremely important to distinguish *macro* descriptive distribution on one hand, and *micro* stochastic process facing individual household and firm. To take macro distribution as constraint on micro optimization does not provide us with correct micro-foundations: see section 2. For example, Nirei and Aoki (2016) consider income distribution in neoclassical growth model. It takes macro equation as constraint on micro optimization, and spoils Champernowne by mixing up the two.

Firm Growth

Size/Growth of firms is another research area where stochastic approach has made significant contribution (Gibrat (1931), Ijiri and Simon (1979)). The basic idea is the same as Champernowne's analysis of personal income. Instead of modeling the optimization behavior of individual firms in detail, they are considered random simply because they are too complex for the third party's viewpoint.

Reinterpreting Y_t in equation (1) as the firm size in period t and letting $X_t \coloneqq log\, r_t$, we consider the (logarithmic) growth rates of firms' sales (i.e, $X_1, X_2, \dots, X_n$) and their sum S_n (i.e., the growth rate over n periods). There are two well-known stylized facts confirmed by previous studies of firm growth dynamics (see e.g., Coad (2009) and Dosi, Pereira, and Virgillito (2017)).

The first is that the distribution of firm's growth rate does not depend on the firm's initial size. In the context of firm growth dynamics, this is referred to as *Gibrat's law*. An implication of this "law" is that $X_1, X_2, \dots, X_n$ are independent and identically distributed (i.i.d.) random variables. Namely, a random walk assumption provides a good approximation for S_n.

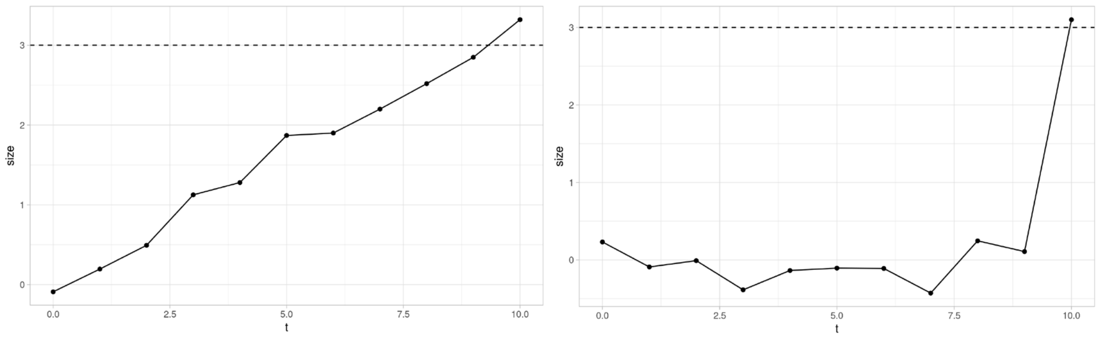
The second stylized fact is that the growth rate distribution has heavier tail compared to the Gaussian distribution. In other words, there is higher probability of extremely large values than would be expected under the Gaussian distribution. Further studies of growth rate distribution have demonstrated not only that it is not Gaussian, but also that the tail of the distribution is heavier than exponential: such group of distributions is called *subexponential*.

Arata et al. (2023) focus on how large values of S_n (i.e., high-growth firms) are generated by n

individual growth rates $X_1, X_2, \dots, X_n$. It is shown that given the two stylized facts explained above, the most likely pattern (sample path) for high growth is not gradual increase as depicted in Figure 2(a), but rather sudden and significant growth due to a single large X_k, resembling a jump as shown in Figure 2(b). To assess the significance of these jumps, the following ratio is used:

$$r := \frac{Growth\, rate\ in\ the\ first\ half\ of\ n\, periods}{S_n}$$

For each firm, this ratio is computed and visualized as a histogram (Figure 3). This histogram shows a U-shaped curve with spikes at r = 0 and r = 1. This U-shaped curve means that when S_n takes a large value, the most probable pattern is that a large jump occurs either in the first or second half of the period leading to abrupt growth. Cases where both the first and second half growth rates contribute equally are less likely to occur. High growth of firm occurs within a relatively short period of time just like a jump rather than accumulation of small growth.



(a) Gradual increase (b) Increase by a sudden jump

Figure 2: The image of sample paths.
The figures are taken from Arata et al. (2023).

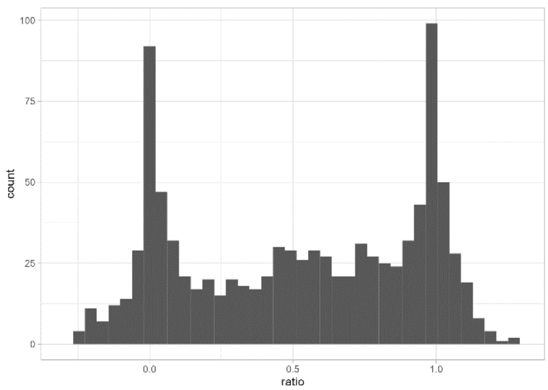


Figure 3: Histogram of the ratio r (n = 2).
The figure is taken from Arata et al. (2023).

What gives rise to this distinctive statistical regularity of the U-shaped curve? It is randomness that generates statistical regularities like the U-shaped curve. We could find the pattern by resorting to stochastic approach. It is important to recognize that optimization on the part of individual firm has nothing to do with the U-shaped curve.

5. Concluding Remarks

Modern macroeconomics is proud of solid micro-foundations. Lucas (1987) argues that economics is one. However, economics must be dual because microeconomics and macroeconomics are fundamentally different. In microeconomics, it is necessary to analyze motives and strategic behavior of consumers and firms in detail, whereas in macroeconomics, it is no use. For the purpose of macroeconomics, micro-behavior is truly heterogeneous and basically unobserved to the third party. Thus, the alleged micro-foundations actually do not make much sense. The fundamental problem is that we can never observe optimization of micro economic agent such as individual household and firm. Introducing such unobservable micro optimization into model is bound to fail leading us to representative agent assumptions. Apparently heterogenous agents in some models differ only to the extent that realizations of relevant stochastic variable are different. It is essentially nothing but stochastic version of representative agent assumption.

What really happened in the name of micro-foundations for the last fifty years is simply the rejection of *aggregate real demand* though it is important, often the most important variable in business cycles. Demand changes much more swiftly than technology or factor endowment. Thus, without demand we cannot understand changes of the macroeconomy.

For example, in growth accounting, we often obtain negative change of total factor productivity (TFP). As long as we stick to the interpretation of TFP as technological shock, we must be at a loss to explain what "technological regress" really is. Some economists only bypass this problem by resorting to measurement errors. The truth is that in the short-run, output falls when demand falls, and hoarding of both labor and capital which prevails everywhere in the economy makes TFP fall.

Macroeconomists in academia are free to play with the Ramsey consumer in the name of micro-foundations. However, the wedge between academic analyses and practical policy makings have widen over years. HANK reviewed in section 2 is meant to offer good guidance on monetary policy. Everybody knows, however, that the Federal Reserve's policy guided by such solidly micro-founded models miserably failed leading the US economy to double digit inflation in 2022. Thanks to representative consumer assumptions, Krugman (1998) could show that central bank can produce inflation amid deflation simply by increasing money stock even if the economy faces to zero interest bound. The decade long experiment of The Bank of Japan (2013-2022) amply demonstrated, however, that increasing money stock or quantitative easing could not generate the target 2% inflation.

Meanwhile, amid COVID-19 turmoil (2021-22), Fujii and Nakata (2021) analyzed interactions of infection and GDP using a simple SIR macro model, and successfully offered indispensable information to policy makers. In 2020, the Japanese government set up the official committee on COVID-19, the headquarter consisting mainly of epidemiologists. Initially, the committee focused on infection in perspective of epidemiology paying little attention to social/economic costs of regulations. Fujii and Nakata (2021) performed simulations based on their simple SIR model, and demonstrated tradeoff between containment of infection and social/economic costs. Their analysis was the only information on social/economic costs used by the committee for the purpose of designing various regulations and the Tokyo Olympic Game held amid pandemic in 2021. Their model is devoid of the Ramsey consumer, not micro-founded. That is why they succeeded. Pandemic is macro phenomenon in which interactions of people play the key role. Such micro behavior is truly unobservable that the Ramsey consumer is of no use for the purpose of exploring infection and the macroeconomy in any meaningful way. Eclectic approach such as agent-based model is necessary. The same principle applies not only to pandemics but to macroeconomics. Solow (2004) calls it "The Tobin Approach".

To understand important macro phenomena such as distribution of personal income and firm growth, stochastic approach is the only feasible one. There is a story that emphasizes the merits of such probabilistic approach: the story of constructing sea dikes in the Netherlands (cf. De Haan (1990)). Since 40% of the Netherlands' land is below sea level, sea dikes are crucial to prevent disasters caused by high tides. Indeed, in 1953, a severe storm caused high tides that led to the collapse of the dikes, resulting in two thousand casualties. Thus, the Dutch government decided to construct dikes that could withstand a once-in-a-thousand-years high tide. To do this, it is necessary to estimate the height of such a once-in-a-thousand-years high tide. Now, how would one estimate the height of such an unprecedented high tide?

An approach many economists might prefer is to model the mechanism of high tide and then estimate the possible height of high tides through calibration. For example, one might attempt to collect detailed information on coastal geography and weather conditions, which could then be used to model high tides. To put it more extremely, if we could know the movement of every individual water molecule, in theory, we could precisely predict the occurrence of high tides. However, it is realistically impossible to grasp all such detailed information. In fact, what proved effective in the construction of the Dutch sea dikes was a probabilistic approach based on *extreme value theory*. According to extreme value theory, the maximum value of n independent random variables is known to converge to a certain probability distribution (an extreme value distribution) (Embrechts et al (1997)). Since what is needed for dike construction is the probability of the highest tide (i.e., this maximum value), they actually estimated the height of the once-in-a-thousand-years high tide based on this extreme value distribution. It is an example where the logic of probability (i.e., the convergence to the extreme value distribution of maximum values) rather than a model based on microscopic details provided valuable information to our society.

Actually, this method has been time and again successful in natural sciences when we analyze object comprising many micro elements. Economists must be still skeptical of the validity of the method in economics saying that inorganic atoms and molecules in nature are essentially different from optimizing economic agents. Every student of economics knows that behavior of dynamically optimizing economic agent such as the Ramsey consumer is described by the Euler equation for a problem of calculus of variation. On the surface, such a sophisticated economic behavior must look remote from "mechanical" movements of an inorganic particle which only satisfy the law of motion. However, every student of physics knows that the Newtonian law of motion is actually nothing but the Euler equation for a certain variational problem; particles minimize the energy or the Hamiltonian! It is called the principle of least action: see Chapter 19 of Feynmann (1964)'s Lectures on Physics, Vol. II. Therefore, behavior of dynamically optimizing economic agent and motions of inorganic particle are on a par to the extent that they both satisfy the Euler equation for respective variational problem. The method of statistical physics can be usefully applied not because motions of micro units are "mechanical," but because object or system under investigation comprises many micro unit individual movements of which we are unable to know. In section 4, we review some successful examples of stochastic approach such as income distribution and firm growth.

Macroeconomics and microeconomics are fundamentally different. In microeconomics such as industrial organization and market for "lemon", detailed analysis of motives and strategic behavior of micro-agents is necessary. However, in macroeconomics, such analysis is no use. To understand macro phenomena, different methodology is required. Research program of standard micro-foundations of macroeconomics is on the wrong track.

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