Chapter 1

The subject matter

This chapter has two main goals. One is to introduce some of the central questions that macroeconomists are interested in. The second is to emphasize an important theme in the text: how our field very fundamentally is an empirical one and that measurement—the ongoing construction and improvement of data sets—and theories addressing the resulting data are intertwined and have evolved in tandem. The chapter also serves to introduce and motivate the empirical and theoretical methods that we use throughout the text.

There are several ways to define the field of macroeconomics, and there is a point to all of them, but they each also come with caveats. One definition is that the field is the study of aggregates. Here an important caveat is that macroeconomics, at least nowadays, is greatly concerned with the distribution of income, the distribution of wealth, and so on, which are not traditionally thought of as aggregates. A second definition is based on methods: macroeconomics is the quantitative study of general equilibrium. Then again, a full general-equilibrium analysis is often not necessary for analyzing many of our core issues. One example illustrating this statement is that most national economies, and even the U.S. are very dependent on the global economy, thus always making the study of a single economy partial to some extent. In addition, a more general point is that, very often, the key component of general-equilibrium analysis turns out to be the characterization of behavior—of consumers and firms—given prices, with the market-clearing mechanism playing a subordinate role. A third definition also emphasizes methods: macroeconomics is the study of the dynamics of the economy, for example by its emphasis on investment and on the role of expectations. However, as we will illustrate in this text, often a static analysis can shed fundamental light on macroeconomic issues. Less of a definition but of equal importance is the fact that macroeconomics tracks current events: the field tends to follow what is perceived as the major issues for our economies at any point in time, whatever these might be. For example, the Great Recession of 2007-2009 had its roots in financial- and housing-market fragilities, and was followed by a "jobless recovery"—a period where GDP rebounded but employment lagged significantly, keeping unemployment elevated and labor-force participation low even as output increased. Since then, these topics have become central to the field and attracted interest from a large number of researchers. The European sovereign-debt crisis of 2011-2012 renewed interest in sovereign default and its macroeconomic linkages—how default risk, sovereign spreads, and fiscal constraints interact with the business cycle. During the unprecedented COVID-19 pandemic, many macroeconomists put their tools to use to ex-

amine its impact on the economy and possible interventions aimed at reducing externalities from social interactions. This involved combining standard dynamic macroeconomic models with epidemiological models of virus spread. Most recently, the 2025 expansion of U.S. tariffs has brought international macroeconomics to the forefront by highlighting how trade policy interacts with exchange rates and global trade patterns via terms-of-trade movements.

The list of definitions of the field is not exhaustive and we think it is useful to use all these perspectives, in addition to the fact that a driver behind macroeconomic research is not only to understand but also to fix problems, if possible, through government policy. For now, the present chapter will be organized around the last point above: the idea is to take you through some important events in the development of our field. This is by no means meant as an attempt to write a doctrine history; rather, the main, and really only, purpose is to illustrate the continuous development of measurement and theory to, precisely, respond to the major needs of our times. Also, we hope that the discussion will illustrate how the focus of macroeconomics keeps moving and touching base with—and, most of all, borrowing insights from—various other subfields of economics, such as labor economics, finance, microeconomic theory, and public economics.

1.1 A random walk along our macroeconomic history

We will now highlight some of the key questions in macroeconomics, along with the need for measurement and theory, and bring them up in the context of some real-world events. The focus, especially when it comes to measurement and where data is collected, is on the U.S.; for what it is worth, there is no deep motivation behind this choice, other than a practical one: most of macroeconomic frontier research has addressed U.S. data. At the same time, it is important to recognize that macroeconomic analysis typically does need to be adapted to the country under study—institutions differ, the role of foreign trade differs, the availability of data differs, and so on. In particular, perhaps, countries further from the development frontier face different macroeconomic problems and we will touch on these in Chapters 13, 23, and 24. Generally, however, we very much encourage you to make comparisons to other countries—both in terms of events and measurement—as you go through the text.

1.1.1 The Great Depression: what is going on?

About one hundred years ago, there were macroeconomists—in the sense of economists who had thought long and carefully about the performance of the economy as a whole—but these macroeconomists had virtually no systematic data to relate to; there were only scattered accounts of some production figures and some prices. What we now know as the national income and product accounts began to be developed in the 1920s and these efforts were made much more urgent by the need for systematic measures of just how badly the economy was doing in and around the Great Depression. The emerging systematic measures allowed macroeconomists to obtain partial answers to the simple question **"What is going on?"** The newly available data therefore helped John Maynard Keynes, and many others following in his footsteps, in their analysis of the macroeconomy and of how there might be ways to use government policy actively to combat recessions. In contrast to the thinking

at the time, Keynes emphasized market imperfections, in particular the sluggish adjustment of wages and prices to changes in market conditions, leaving room for a decline in the demand for consumption and investment to affect production. Simple theories connecting our now-observable main aggregates—output, consumption, and investment, private and public—were thus developed, and they remain influential today.

Constructing our aggregate data is not an easy task, however, and many of these early measurement efforts were major research achievements with important contributions from Colin Clark, Simon Kuznets, and Richard Stone. Let us now briefly describe some of the results of this work.

What do we measure?

The main purpose of national income accounts is to measure "what is *really* going on" in terms of quantities of goods and services produced. To aggregate many types of goods, we use their nominal values so the national accounts are most directly measured in nominal (current dollar) terms rather than real terms. An important question was how to compare national aggregates across time. At a general level, the answer is straightforward: we must develop a measure of the general level of prices, a price index, to separate nominal changes into quantities and prices. Once we adjust for the change in the general price level we obtain measures of real production.

Price index construction

A price index is, generally speaking, a weighted average of prices with weights corresponding to the importance of different goods as measured by the share of total expenditure spent on them. In constructing a price index, one must make some choices: the weighted average could, for example, be arithmetic or geometric and the expenditure shares could be taken from a base year or could be evolving over time.[a] These choices are often guided by microeconomic theory. For example, in Chapter 6 we will derive a price index for a consumer with a constant elasticity of substitution between goods. In that context, the price index is inversely related to the utility a consumer obtains from a given level of total expenditure.

[a] E.g., they could be straight averages of the current and last year's shares, as in the Törnqvist index.

Gross domestic product (GDP) is not a welfare measure; rather, it is a measure of how much the market economy is producing. GDP does not take many relevant sources of utility into account as they are not market-produced goods and services. Leisure, along with many environmental amenities and illegal transactions, are not counted. The difficulty in incorporating these non-market activities is that it is very hard to know how to value them. In contrast, market activities have values measured in common units (dollars).

National income and product accounts

The accounts follow double-entry methods: they measure both expenditures and income. That is, someone's expenditure is always someone else's income, allowing double-checking.

GDP can thus be seen either as the sum of all final expenditures (private and public consumption and investment plus net exports) or as the sum of all incomes. It can also be calculated as the sum of values added by all firms. A firm's value added is its revenue from sales less its expenditure on intermediate inputs bought from other firms. The reason for not including intermediates is to avoid double counting: if one firm produces a fully equipped car, except for its exterior paint, and the second firm buys the car, paints it, and sells it, a sum of these two transactions would be close to twice the final value of the car and, thus, not be a good measure of the economy's car output. As a firm's value added measures its production, GDP is also equal to the market value of all production.

The two broad categories for income are labor income and capital income: wages and salaries and profits, interests, and dividends, respectively. Note here that profits for firms that, say, extract and sell oil, are counted in full; the resulting decline in the stock of natural resources is not deducted. For this reason, GDP is sometimes reported with a deduction for "natural-resource rents."

Capital (equipment or structures) is an intermediate good in some sense—it is bought as an investment good by a firm and used as an input in future production—but expenditures on capital are treated as final expenditures and therefore counted in GDP. This observation actually suggests that when GDP is measured for longer time periods, it should perhaps treat capital differently. Capital income should, then, be a smaller share of total income, and GDP would be correspondingly smaller since it would count some of the investments—at least those that depreciate fully within the now longer period—as intermediate goods instead.[1] With this perspective, over longer time periods, GDP averages should perhaps receive less focus than average consumption.

The pandemic: what is going on?

A parallel to what occurred during the Great Depression—another **what's going on** question—took place during the COVID-19 pandemic when economies underwent massive changes overnight. Economists sought new high-frequency measures of activity in order to measure the economy in real time. These efforts often made use of transaction and commercial data gathered by companies in the normal course of business. For example, credit card companies can measure the spending patterns of their customers nearly in real time and the resulting data have made their way into macroeconomic analysis. The availability of credit card data has also proven very valuable for other reasons: to measure consumers' propensities to consume, say, when they receive transfers from the government.

1.1.2 Keeping track of long-run growth

By the mid-1950s, the economy was more or less back on its track and now there was a sufficient amount of aggregate data that it was possible to analyze its growth performance. Robert Solow's 1956 paper—the basic neoclassical growth model—and his 1957 paper on

[1] Conceptually, it should be the depreciation rate of capital goods that is key and that, at any frequency of sampling, determines whether it is to be regarded as capital or an intermediate good. In the 1990s, the national accounts started treating "software" as investment, as opposed to an intermediate good; the line between these two categories is sometimes quite thin.

growth accounting became the impetus for a burgeoning literature on economic growth that was both empirical and theoretical. The idea in Solow's growth-accounting paper is that one could use measures of output and inputs, along with the prices of inputs, and a basic theory of production to break down aggregate growth into the contributions of each input and, finally, a residual, which could be thought of as technical change: the *Solow residual*. It was due to the systematic measurement of quantities and prices that this kind of analysis could now be performed.

Which factors, then, accounted for most of U.S. growth? Solow found technical change to be of great, and direct, importance. However, in accordance with his 1956 theory, capital accumulation was an indirect result of technological change. This theory went beyond accounting and concluded that technological progress is the one (and only) fundamental reason why growth in output keeps rising over time.

One reaction to the empirical finding was that whereas it was plausible that technological change is key to growth, its importance may have been overstated; after all, it was measured as a residual, and if input growth rates were underestimated, the role for technological change would not be as large. A particularly likely reason for this was that workers' skills were improving; there was an ongoing trend of increased schooling and work experience—"on-the-job learning"—was thought to contribute to worker productivity as well. In 1958, labor economist Jacob Mincer wrote his influential paper relating individual wages to years of schooling and experience and found very strong regularities in the data that have been imported and used in constructing better measures of labor input: "human capital." The so-called Mincer equation, which can be derived based on a simple opportunity cost–based theory, says in its estimated form that one more year of schooling adds a little below 10 percent to your wage. Another important measurement development in the growth-accounting literature was the notion of a firm's user cost of capital; firms buy capital and often own it until it gets scrapped, so how should one measure the "year-by-year price" of this input? Hall and Jorgenson (1969) developed an answer that was consistent with microeconomic theory and has been used ever since.

The growth-accounting literature developed virtually into an industry, where productivity performance was computed and accounted for on a disaggregated level. A natural accompanying project was to construct similar data series across countries and compare them. In 1978, Kravis, Summers, and Heston published a paper with comparable data series for 100 countries, an effort that was later continued and today takes the form of the Penn World Tables, a crucial data source for students of economic growth. In a related effort, Maddison used various sources of data to estimate GDP levels for a range of countries going back into the early nineteenth century. Harmonizing data across countries is challenging, and comparing real output too: should nominal outputs be compared in real terms by use of nominal exchange rates? Because the purchasing power of different monies vary by country, as it does within countries too, a so-called PPP adjustment gradually arose as a new standard; we discuss it and its implications in the growth chapter.

As a result of the multi-country data sets, new light could now be shed on the process of growth; in particular, **what made some countries grow so fast and others stagnate?** The endogenous-growth literature of the late 1980s and 1990s asked these questions, which were partly phrased as challenges to the Solow model. The endogenous nature of technological change—in particular how it is driven by incentives to innovate—as well as of human

capital accumulation came into focus, first theoretically and later empirically. Today, for example, we have access to large patent data sets that are currently under the magnifying glasses of hordes of researchers. Some of these data sets contain information on individuals so questions such as **Who becomes an inventor?** now occupy many macroeconomists.

An aspect of economic growth is **structural change**. Structural change typically refers to how some sectors shrink over time and others grow; roughly speaking, a typical path is one where countries gradually build their income—and "develop"—starting with agriculture as a dominant activity, gradually then moving into manufacturing, and finally growing the service sector. Today, agriculture only employs a percent or so of the total workforce in the U.S., whereas in the poorest countries in the world the number is 80 percent; manufacturing has furthermore been overtaken by services. Today, many macroeconomists worry about another expression of structural change: how information technology (IT) changes the workplace. In particular, **what are the implications of automation and artificial intelligence (AI)**, for macroeconomic performance, for inequality, and for the competition between firms?

Another element of structural change is women's labor-market participation, which has risen steadily and significantly in the U.S. over the whole postwar period and stands at a very high level today (not quite as high as that for men, but close). In contrast, it is much lower in many other developed countries, though it is also high in a number of countries at a lower level of development. The government sector—its size and role—can also be depicted as part of a process of structural change, as can international trade, both for a given country and for the global economy. An important ambition of macroeconomists studying medium- to long-run issues is to analyze the sources of these changes as well as their effects. An element they have in common is that they are slow-moving and never causes of immediate media attention, but nevertheless crucial for our economic welfare.

In sum, research on economic growth appears to have come in waves, where theory and measurement interact in very central and mutually reinforcing ways.

1.1.3 The 1970s: an oops, with stagflation, high unemployment, and more

The post-war period up to the early 1970s was generally perceived as one of steady growth and increased prosperity. As for macroeconomic policy, the Keynesian recipes were adopted in most countries in the form of regular interventions to stabilize the economy; the term *fine tuning* was often used. Then came an "oops": the sharp recession in 1973, along with a number of severe macroeconomic problems that ended up being quite persistent. Although the cause-and-effect question is still debated, many interpret the events as a result of the oil-price hike orchestrated by OPEC in October of 1973, and the challenging era that followed was not specific to the U.S. but shared by most of the western world. Two primary difficulties involved lackluster GDP performance—along with a slowdown in productivity that at the time appeared permanent to many (the "productivity slowdown" period)—and sharply rising inequality. The effects on inequality in the labor market had different expressions in different countries: in the U.S. and the U.K., wage inequality rose sharply, while in many other EU countries unemployment rose to very high levels and stayed high for many years.

Interestingly, a new development in theory, that would turn out to have a large impact

on macroeconomics, occurred in the early 1970s, before the drastic downturns in aggregate activity occurred: the development of search models in labor economics (McCall, 1970, and Mortensen, 1972). This was to become one of the cornerstones of a theory of unemployment that later was adopted in macroeconomics as we discuss in Chapter 20. The measurement of the concept of being "unemployed" goes back in time much further, to the late 1930s; the new search theory in the 1970s benefited immediately from available data. However, the interest of macroeconomists in the topic rose sharply during the productivity slowdown period and generated further data needs. Today, a central part of our analyses of unemployment includes detailed data both on individuals and on firms, most of it in survey form. Moreover, keeping track of inequality trends, such as the average wage gap between skilled and unskilled labor that took off beginning in the second half of the 1970s, has become a central activity for macroeconomists.

Labor-market data

Much of our information on the labor market comes from surveys. Total labor income is available from NIPA but how it breaks down into employment, hours worked, and wages/salaries for different workers is all based on how individuals answer questions in questionnaires. A key source is the Current Population Survey (CPS), conducted monthly by the Bureau of Labor Statistics (BLS) in collaboration with the Census Bureau. The CPS has a (limited) panel feature, i.e., it interviews the same people at more than one point in time. The CPS also measures unemployment, i.e., it asks people if they are not working and looking actively for a job, in line with search theory. An important source of data on individual labor-market outcomes is the Panel Study of Income Dynamics (PSID), conducted by the University of Michigan, started in 1968: it follows individuals over a significant amount of time and has data on a number of individual variables, all self-reported. The breakdown of labor earnings into hours worked and a wage per hour in these data sets is based on individual reporting on how many hours they work. Other panel data sets on individuals include the National Longitudinal Survey (NLS, conducted by the BLS) and Survey of Income and Program Participation (SIPP, conducted by the Census Bureau).[a] Firms are also surveyed and report work hours for their employees (e.g., in the Annual Survey of Manufactures from the Census Bureau), but then the same workers may have multiple jobs so measures of how much an individual works in total still rely on asking the individual. Around the turn of the millennium, and in part as a result of the new developments in the field of macro labor, where search frictions for firms and workers are in focus, the BLS also has started to publish data on labor market flows in the Job Openings and Labor Turnover Survey (JOLTS). This data set has since become invaluable in the evaluation of further developments of our theories.[b]

How individuals spend their total amount of time is also measured. Since 2003, the BLS has produced the American Time Use Study (ATUS), a survey documenting daily activities in great detail, including how much time is leisure versus various forms of "work at home." Using ATUS, it is also possible to find out not only whether people

searched for jobs, but how much time they spent on this activity.

[a] A longitudinal survey is a panel, i.e., a study that follows the same individuals over time.

[b] Today, data from labor markets—e.g., recent trends, particular skills in demand—are also provided commercially, often with real-time information from the internet, and used by human resource departments and head-hunting agencies.

Governments attempted to stabilize the fall in GDP, in particular with expansionary monetary policy, i.e., by cutting interest rates. However, there was very limited success; rather, the 1970s was also a period of unusually high inflation (with annual rates in the 10-20 percent range in many countries, and even higher for some). The combination of stagnation and inflation was dubbed *stagflation*. The Keynesian paradigm came under increasing scrutiny and a number of economists focused on weaknesses in the Keynesian theory itself. A particularly powerful point was the "Lucas critique," which explained how reduced-form relationships between aggregates—a cornerstone in the applied Keynesian apparatus—could break down if policy changed. The Phillips curve—the negative relationship between the inflation rate and the unemployment rate—was a particular case in point: in a paper that actually predated the oil crisis and stagflation, Lucas (1972) advanced a theory showing how attempts to exploit this seeming trade-off with monetary policy would make the relationship itself break down. When the relationship did break down, Lucas's sharp critique gained added force and, in hindsight, marked a clear break in the development of macroeconomics.

Curiously, the 2021–2022 period echoed the 1970s: a sharp rise in headline inflation, amplified by an energy price shock linked to the Russia-Ukraine war. This prompted fears of a new stagflation period. However, major central banks around the world raised interest rates sharply in 2022–2023. By late 2023 and into 2024–2025, inflation fell back as energy costs eased and supply bottlenecks decompressed, while labor markets stayed relatively tight. As a result, the feared stagflation did not materialize. Undoubtedly, macroeconomists are better equipped today in confronting these kinds of episodes, but every challenge seems to have its unique properties.

1.1.4 Kydland and Prescott: a way forward

Lucas's critique was not just destructive, in pointing to weaknesses in the Keynesian approach, but he suggested, at least conceptually, how an alternative framework could be built. The idea was to build explicitly on microeconomic theory, and with Kydland and Prescott's 1982 paper (see Kydland and Prescott, 1982) it became clear just how to do this in a way that also allowed systematic comparison with data: they offered *quantitative theory*. This paper suggested basing the microeconomics on empirical studies in applied fields, such as labor economics and consumption studies, not just in terms of the structure but also by importing parameter values from the empirical microeconomic literatures. Kydland and Prescott's paper, which led to an explosion in macroeconomic studies, also added another important aspect of measurement: that often, data needs to be detrended, or "filtered," in order to be ready for analysis, in their case in examining the sources of business cycles.

Filtering

When macroeconomic models are built and compared to data, the data are almost always filtered first. To understand what filtering means, you need to see macroeconomic models as dynamic systems, i.e., as some form of vector difference equations, that contain random variables. Thus, macroeconomic models in fact define a *stochastic process*. Such a process could therefore be simulated by the researcher and, in principle, compared to data. However, the idea is rarely that the theory is constructed to explain everything. Kydland and Prescott, for example, were interested in recessions and booms, which are movements upward and downward in macroeconomic aggregates around some overall trend, but this trend was not the subject of their study. In order to compare theory and data, most researchers therefore use filters to extract the aspect of the data they are interested in analyzing. To do this, theory comes in handy: stochastic processes can, quite generally, be thought of as sums of sub-processes, each one with a different frequency, i.e., periodicity. For business cycles, one thinks of periodicities of between 1.5 and 8 years perhaps, and so-called band-pass filters offer can be used to take any data series and remove any frequency outside a specified range. In contrast, studies of medium- to long-term movements in variables require removing high frequencies and retaining low to medium frequencies.[a] In financial economics, when day-to-day or minute-to-minute changes in stock prices are analyzed, all but the very high frequencies are removed before the data can be analyzed.

[a] Kydland and Prescott (1982) used a specific filter: the so-called Hodrick-Prescott filter, which is an intuitive way of extracting data. It has very wide-spread use in macroeconomics.

Kydland and Prescott's theory of the business cycle was quite stylized and stripped down—among other things, it was phrased entirely in real terms and had no role for monetary policy—and the literature that followed enriched their framework in many directions. A key point here is that the first wave of models had perfectly working markets; later, a number of frictions were added and today, virtually no macroeconomic model that is used in practice is free of market imperfections. A key friction that was added was price stickiness: firms setting dollar prices of products face costs in doing so, and therefore only adjust prices infrequently. This makes monetary policy have direct effects on the economy, something it might otherwise not have. Thus, the "New Keynesian" framework was built up, where monetary policy is in focus. Again, the new theory led to measurement efforts. In particular, studies such as Bils and Klenow (2004) looked at the survey data available underlying the CPI and recorded the frequency of price adjustments; their work allowed researchers to parameterize the microeconomic structure for adjustment costs assumed in the models.

1.1.5 Different waves of macroeconometrics

The comparison between models and data has also undergone waves. As with much of economics, it is challenging to discern causal relationships in the historical data given to us. As more and more data have become available, however, more and more thinking has been devoted to the development of different statistical methods for doing this. A central question

has been the purely methodological one of how historical macroeconomic data can be used to make inferences; for this reason, we devote significant space in this text to the methods used today (see, especially, Chapter 8).

Macroeconomic models are all simplifications of a highly complex system and therefore there is little point in "testing a model" by assessing whether it can be the true data generating process. As the saying goes, all models are wrong but some can be useful. A useful model allows us to answer an important question in a convincing way and the model must be consistent with the relevant data we can observe in order to be convincing. Of course, if the answer to our question can be directly observed then there is no point using a model. So a useful model allows us to bridge the gap from the data we observe to the questions we want to answer. Knowing which data are important to match in order for the answer to be convincing is often argued to be an art. But art, too, can be taught.

The empirical implementation of Keynesian theory involved estimating large systems of (usually linear) relationships, often with ad-hoc specifications of short-run dynamics, i.e., with lags of variables added so as to provide a better fit. Sometimes instrumental variables were used, but that was more uncommon. The critique that came in the 1970s forced macroeconomists back to the drawing board. One approach was to estimate the new, now microeconomics-based, structural models that rapidly developed using classical statistical methods. A literature using maximum-likelihood and Bayesian techniques for estimation was developed; a related development involved use of the generalized method of moments, which could be applied to a subset of the model's equations.

Another theory-based path, labeled calibration, was the method favored by Kydland and Prescott in their work. The calibration approach is very common in current macroeconomic research and can be used to derive quantitative conclusions from a theoretical model. For example, in their work on business cycles, Kydland and Prescott wanted to know to what extent movements in technology could generate fluctuations in aggregates that resemble those in the data. The spirit of calibration is to select the model's parameter values based on other moments of the data than those in focus in the study. For example, Kydland and Prescott based their parameter choices on two kinds of data: (i) micro data, e.g., for people's attitudes toward risk and intertemporal substitution; and (ii) long-run facts (that is, low-frequency data not in focus for their high-frequency interests). Once the model parameters have been selected, one can then derive the model's predictions for the phenomenon of interest. For example, Kydland and Prescott calculated the variances and correlations of aggregate variables to assess whether the model could generate business cycles that resembled those observed in the data. The sentiment of "all models are wrong" may explain the wide use of calibration within macroeconomics. Calibration does offer discipline in the sense described above—parameters are not to be chosen to match the moments the researcher wants to explain—but, at the same time, does not lend itself to hypothesis testing.[2] Relatedly, as all models are wrong we are more interested in the broad patterns they predict: can the model at all account for the phenomenon under study, or are the magnitudes severely off? If the model can generate patterns similar to those in the data, it is typically judged "potentially useful"

[2]The lack of hypothesis testing is shared with Bayesian analysis. Of course, in Bayesian analysis, the parameter selection is informed by the data under study; in calibration it is not: all the weight is on the prior.

and elaborated on further, possibly adding detail and examining auxiliary implications. This is how "technology shocks" entered our vocabulary and are, still today, considered relevant for (but far from alone in) explaining business cycles.

A much less structural approach was proposed in Sims (1980): vector autoregressions (VARs). Sims's focus was much more on the identification of causal effects in aggregate data, and the core of his methods involved ways to observe plausibly exogenous shocks, such as an unexpected increase in the Fed funds rate, and then trace out the effects of the shocks on macroeconomic variables, including the effects on the subsequent movements in the rate. In its simplest form, a VAR is a linear system of variables including lags, containing both intra- and intertemporal relationships, and a shock to each variable at each point in time. A literature also evolved that took structural models and derived their linearized VAR approximations, which could then be compared to the estimated VARs as well as offer some structural interpretations of some the coefficients in the VAR. VAR analysis is a very common tool in macroeconomics.

Another approach to identifying causal effects is to use natural experiments. Increasingly, macroeconomists use information from natural experiments to identify the strength of causal relationships at the microeconomic level and use these moments as targets when calibrating a macroeconomic model. An important example is measuring the marginal propensity to consume out of wealth. In 2001, the U.S. government paid tax rebates to most households and randomly gave some households their payments sooner than others. Johnson, Parker, and Souleles (2006) used the random timing of the payments to measure how strongly consumption spending responds to additional income. This type of information is now an important calibration target for many macroeconomic studies as the marginal propensity to consume is important for understanding the effects of certain government policies. In this case, the natural experiment occurs at the level of the household as some households are paid earlier than others. Natural experiments at the level of an entire economy are more rare but there are some examples. One type of application is exemplified by Acemoglu, Johnson, and Robinson (2001), who used excerpts of historical records from the colonial era to make causal statements about the effects of institutions on long-run economic growth and well-being. Another example is the "narrative" approach to the evaluation of monetary policy, where minutes from Federal Reserve meetings are analyzed to identify exogenous events affecting Federal Reserve policy (Romer and Romer, 1989). The Romer and Romer study is an example of another phenomenon, which is to use text analysis (e.g., words used in media) in macroeconomic contexts; the wave of big-data tools has also entered our field.

1.1.6 Models: intuition vs. quantitative use

Kydland and Prescott's work was a game changer also in how macroeconomists approach model building, which previously had been largely oriented toward building an intuitive understanding of mechanisms—such as Lucas's 1972 Phillips-curve paper. Of course, there are a huge number of different mechanisms at play, so how does a macroeconomist oriented toward giving policy advice choose which mechanism(s) to focus on? Kydland and Prescott's answer was to move away from building models aimed at intuition in favor of larger models that could be parameterized and calibrated to deliver quantitative output. This quantitative output would then, within a single model, aggregate across the many mechanisms inherent

in the model. The analysis of larger, nonlinear, models is much harder and, with sufficient complexity, impossible to undertake with "pencil and paper." Thus, a new sub-field of macroeconomics developed rapidly: that focusing on solving dynamic models with numerical techniques. Nowadays, the most common approach in applied macroeconomics is arguably to formulate rich models allowing several mechanisms believed to play a role, solve the models numerically, and then simulate them to study model output and compare different mechanisms quantitatively. This approach has not replaced the need to formulate much smaller models to build intuition, but the aim is to ultimately be equipped not only with an intuitive understanding of what goes into building the macroeconomic equivalent of a bridge but also with quantitative assessments that allow us to cross the bridge without fear.

1.1.7 Macroeconomics and inequality

As already mentioned, the late 1970s saw sharply rising wage inequality, a phenomenon that has continued, though with different intensity, and hit different groups differently, during different decades. **What explains these developments?** Technological change, increased exposure to trade, or changes in unionization? Many macroeconomists have turned their attention to this question. They have developed theory and examined how different theories match the data, making the overlap with labor economics a particularly vibrant one. Here, data on individuals has been a key input.

Microeconomic data and administrative data

Macroeconomists commonly use microeconomic data that report outcomes at the levels of individual people, households, firms, or other microeconomic units. Such data can be used to understand the heterogeneity among individuals. One application is simply to document the distribution of outcomes across. For example, one can measure the dispersion in income or wealth across households. A second use of such data is to inform micro-founded models. Microeconomic decisions occur at the level of individuals and modelers increasingly build models that incorporate heterogeneous agents. To discipline these models we often need data that describe the risks and incentives at the microeconomic level.

Survey data was, for many years, the main source of micro data for economists. In recent years, it has been increasingly common for researchers to access administrative data assembled by government agencies. Administrative data is collected in the course of administering taxes or government programs. For example, tax authorities collects data on taxpayer incomes for the sake of administering the tax system. Administrative data is typically more accurate than self-reported survey responses. Moreover, administrative data sets are often much larger than surveys are; sometimes covering the entire population. The data quality and sample sizes allow for more accurate and more detailed research. Administrative data is anonymized before being used by researchers, but nevertheless privacy concerns mean access to administrative data is tightly controlled. In addition, administrative data is often narrow in scope (e.g. the tax authority does not know your level of education). For these reasons, survey data remains an important

part of macroeconomic research.

In recent years, researchers have increasingly had access to data from businesses. For example, Grigsby, Hurst, and Yildirmaz (2021) document patterns in wage adjustment from the records of a large payroll processing company. Another recent trend is for researchers to conduct custom surveys that speak directly to the research question.

In one strand of the literature, the focus has been on data sets that contain detailed information both on firms and on their employees, hence shedding light on what kinds of firms "match" with what kinds of workers and how wages are then set and vary over time. Although the share of total income paid to labor has been remarkably stable during the postwar period in the U.S., it has had a **recent trend downward** over the last decades, a trend that can be observed also in many other countries. Hence, macroeconomic researchers are examining various hypotheses for this phenomenon, such as structural change and technological change, possibly along with changes in the degree of competition. To this end, access to data on firms is critical, and the overlap with the field of industrial organization is increasing.

Firm data

Various firm-level (and establishment-level) data sets are provided by both governmental institutions and commercial vendors.[a] In the U.S., the Census Bureau and the BLS provide data from administrative sources and from surveys. We can obtain information about (among other things) entry, exit, and employment dynamics of firms and establishments at annual and quarterly frequencies. Although micro-level data are often confidential, many useful summary statistics are publicly available.

Some of the data sets include information about inputs and outputs on the firm level. Among other things, these can be of use for estimating firms' marginal costs, which are never directly observable; their movements over time are important for understanding macroeconomic phenomena. Relatedly, innovative activity can be measured based on firms' R&D expenditures, and the patents generated can be accessed from the patent office. As patents build on earlier inventions, the number of times a patent is subsequently referenced by later patents gives a measure of its impact.

[a] Commonly used commercial vendors include Compustat, Orbis, and NETS.

Over the last two decades, we have also observed a sharp increase in macroeconomists' interests in **wealth inequality**. Just like during the Great Depression, a common perception has been that of increasing gaps between "rich" and "poor," along with various forms of polarization, but what does the data—to the extent we even have it—really say about wealth inequality? There are (at least) two reasons for macroeconomists to care about this question, and about the underlying trends driving wealth inequality to change over time. One is an intrinsic interest in inequality as a key aggregate phenomenon: the view that it is an undesirable feature in society and should be taken into account even if it is in conflict with other goals. An additional intrinsic reason is political stability: as expressed in Piketty (2014), one may worry that democracy is threatened if inequalities rise above certain

levels. As a final example, one dimension of inequality of relevance in macroeconomics is that between women and men and across racial and ethnic groups; we are now seeing an increasing number of contributions documenting and analyzing, in particular, how the relative wages and the relative hours worked across groups have evolved over time.

A second reason for macroeconomists to care about inequality is that it captures heterogeneity that is important to take into account when examining the workings of the macroeconomy. When, for example, a tax rebate is implemented with the purpose of stimulating consumer spending, we have reasons to think that cash-constrained, poorer households would spend a large fraction of the rebate whereas richer households will save most, if not all, of it. Thus, distributional data on wealth appears as a determinant of the efficacy of many policy interventions. The development of so-called heterogeneous-agent models, which began in the 1990s and has generated a very large literature, is a response to both these reasons to keep track of, and understand, wealth inequality.

Measuring individual wealth

In the U.S., since wealth is not taxed, there is no direct administrative data on it.[a] The Survey of Consumer Finances (SCF), conducted by the Federal Reserve Board, is available every three years since 1983 and has data on individual assets; it is a key source of information about the wealth distribution. Unlike some of the surveys mentioned above (such as the ASM), this survey is voluntary, but efforts are made to make it representative. The IRS administrative data has capital income, so it is possible to estimate wealth by observing the annual income it generates—if one is willing to assume a rate of return on the wealth. This is called the *capitalization* method. More recently, measures of wealth inequality across countries have been put together by the World Inequality Lab by combining national accounts and sectoral balance sheets with household surveys, fiscal/tax data, and "rich lists" (see https://wid.world/).

[a] A small set of countries have taxed wealth over various periods in time and therefore have administrative data on it.

As it turns out, the various different sources used by different researchers do indicate a rather significant increase in wealth inequality in the U.S. beginning in the late 1970s. Similar trends have also been documented in a number of other countries. In sum, macroeconomics today, is concerned with a much broader view of inequality than in the past.

1.1.8 Taxes and government activities

Many western countries, including the U.S., have experienced slow, long-run increases in the role of government, both when it comes to its total share of GDP and employment and in terms of transfers, such as social security and welfare systems more generally. Thus, the **nature, determinants, and effects of taxation** have become a central theme for macroeconomists. In the U.S., marginal tax rates were increasing and peaked shortly before Ronald Reagan took office and thereafter the degree of progressivity was lowered significantly, and has stayed at a historically low level since. The taxation of corporate profits has also

changed over time. How have these changes affected hours worked, economic activity, and inequality? These questions preoccupy many macroeconomists.

Aside from these changes over time, an overall key question, aside from the degree of progressivity of the tax code, has centered around the choice between different tax bases: taxes on capital income, taxes on labor income, corporate taxes, indirect taxes (such as sales taxes), seignorage, property taxes, and so on. That is, macroeconomics and public finance intersect in important ways. At the same time, the expansion of government activity has increasingly been financed through public debt, prompting a large literature on how debt interacts with the macroeconomy, such as potential crowding out of private investment and capital accumulation, concerns about debt sustainability and fiscal limits, and, in some settings, the risk of sovereign stress and default.

When it comes to the efficiency features of different tax rules, there is also an important overlap with economic theory. For example, it may be tempting to use tax and transfer schemes to fill in where private insurance markets appear to be missing—hence improving the economic situation of those experiencing unexpected adverse events—so macroeconomic policy making may need to address moral hazard and adverse selection. Another challenge, which has been a major issue in macroeconomic research at least since the 1970s, is the fundamental inability of governments to commit to its future policy choices. For example, basic public finance theory says that it is efficient to levy taxes on already installed capital—since it is not distorting any choices—but, if firms/investors know in advance that their capital will be taxed in the future, current investment is distorted. Thus, the government would like to say that it will not tax capital in the future, but, ex post, change its mind. This is known as a *time inconsistency* problem. The tensions inherent in differences between a government's optimal plans and their ex-post temptations to change them has generated another vibrant area of research with significant components of economic theory.

As expectations of future monetary policy are thought to have a strong influence on current inflation outcomes, time inconsistency problems can easily arise in monetary policy too. In short, there could be an incentive to promise to be tough on inflation in order to shape expectations, but then when the time comes there is a temptation to renege on that promise. Considerations such as these have shaped the institutional structure of central banks in many countries. Central bank independence and inflation-targeting strategies are intended to enhance the power of monetary policymakers to commit to sound policy thereby delivering better outcomes for the economy. These institutional features reflect the lessons learned from the experience of the 1970s and 80s. During those years, inflation expectations drifted higher contributing to the stagflation outcomes until central banks eventually renewed their commitments to inflation stabilization thereby anchoring inflation expectations. More broadly, the interactions between macroeconomics and politics is another relatively recent sub-field of macroeconomics where significant research is carried out.

1.1.9 The Great Recession: another oops

In 1979, in an effort to end the high-inflation era, the new Fed chairman Paul Volcker announced, and implemented, a period of very tight monetary policy. Most macroeconomists attribute the ensuing recessions in the early 1980s to this change in monetary policy stance. Inflation did come down, and it did so also in most other western countries; the stagfla-

tion period had been a worldwide phenomenon. In Europe, steps were gradually taken toward tighter monetary policies as well and a currency union was eventually created: in 1999, ten national currencies ceased to exist and the euro took their place. This was a period of financial integration not only among European countries, but also between developed and emerging economies. Restrictions to the movement of financial assets, goods, and services were loosened, triggering a "globalization" process that generated great interdependence among economies. From the mid-1980s and for over two decades, until 2008, the U.S. economy experienced recessions but they were minor and the overall aggregate performance was viewed to be very satisfactory. In 2002, macroeconometricians James Stock and Mark Watson dubbed this era the Great Moderation: a period of time when the macroeconomic aggregates displayed healthy growth and very low volatility. By some, the Great Moderation was attributed to the new and transparent policies followed by the independent Fed. Researchers also advanced other hypotheses that were more structural, such as changes in the nature of technological change. Furthermore, the stabilization frameworks used at many central banks now relied on the New-Keynesian macroeconomic model: a setting based on microfoundations and including a number of frictions, most importantly sticky prices and sticky wages. A prescription from these models was for the central bank to systematically counteract macroeconomic shocks so as to lower volatility and improve our welfare.

Whatever may have caused the Great Moderation, there is no doubt that few expected the events that surprised the world in 2007: a severe economic downturn that was worldwide as well. The recession was nowhere near as deep as the Great Depression, but it was nevertheless a very problematic period: unemployment rose sharply and only fell back very slowly in a manner that was uncharacteristic, compared at the very least to recent experience. The crisis immediately hit Europe as well, and in 2009 a multi-year debt crisis, sometimes labeled the eurozone crisis, was set off. A number of European countries thus suffered from high national debt levels and difficulties in rolling over their debt; this period was one of significant uncertainty. The uncertainty partly involved what paths government policy would take, and there was ample speculation that some countries would leave the currency union. In the end, they did not, but the crisis was long and painful, as were the macroeconomic and political debates about whether debts should be forgiven or not. The crisis highlighted the potential problems of a globalized economy, triggering some countries to 'close down.' The exit of Great Britain from the European Union, labeled "Brexit," was the most notable example. An important role in combating the crises was played by central banks, but now with methods very different than those pursued during the previous decades.

A period of time of intense research followed. **What were the deep causes of the Great Recession?** How could it have been avoided? Were our main theories flawed? This research is still ongoing so it is hard to draw definite conclusions, but there is consensus that a combination of excessive risk-taking in housing markets—arguably rooted both in private and government decisions—and severe frictions in financial markets together slowly sowed the seeds of the downturn. Indeed, the term Global Financial Crisis is equally often used to refer to these developments.

As a result of the experiences during this period, massive research has gone into studying the workings of financial markets and financial institutions and how government regulation affects their performance. It reminded us how asset markets, debt buildups, and (excessive?) risk-taking can be intricately intertwined with the workings of the macroeconomy. The

downward trend in the real interest rate is a related phenomenon. It is suggested to be connected to more severe asset-price fluctuations, including the formation of price bubbles; here the emergence of cryptocurrency is perhaps particularly noteworthy.

Financial data

One of the key questions in this part of macroeconomics is *financial stability*. In particular, if key financial actors have strong interdependencies in their asset portfolios and liability structures, then domino effects can occur, whereby relatively minor shocks can have severe aggregate consequences. As an example, the house-price decline and the resulting defaults on mortgages in the U.S. during the Great Recession were significant, but their quantitative magnitudes were quite small compared to many other asset-price movements throughout history that barely even generated recessions at all. The reason why the small shock had major consequences was to be found in how mortgage liabilities had been packaged and distributed among key financial actors, all of which was quite opaque not just to policymakers but to market participants as well. Hence, the need for data in this area is, and was, great, and a major challenge is that high-frequency data on portfolios is proprietary information and, when it is available, can be hard to interpret.

In its Flow of Funds section, the Federal Reserve Board produces the quarterly Financial Accounts of the United States, a comprehensive set of accounts that includes detail on the assets and liabilities of households, businesses, governments, and financial institutions. These are aggregate data, allowing us to track, among other things, trends in indebtedness—which was key in the analysis of the Great Recession, but also not quite sufficient for detecting interdependencies among financial institutions. There are also data on individual households and firms; the SCF is discussed above.[a]

Asset prices and returns for publicly traded firms are of course available from numerous sources. Assessments of values for non-traded firms are much harder to come by, and even many large firms are not publicly traded. In the past, a typical path from the birth of a firm to an established, large company involved a mix of individually provided funds, bank loans and possibly bond issues, with an eventual public offering and public trading. Today, the path toward public trading of the firm's equity often takes longer and goes via private equity financing, e.g., via venture capital companies.

How private individuals make portfolio decisions is another important input into how the macroeconomy works, but raw data on this is much harder to come by; as discussed above, data on wealth management is typically not available except in limited surveys.

[a] An often-used financial database for firms is Compustat, a commercially provided service containing information about publicly traded firms (also outside the U.S.). An even larger database is Orbis, which also contains non-traded firms, including smaller businesses.

Though it seems clear by now that the basic macroeconomic framework was not abandoned as a result of the Great Recession, it is equally clear that it has been changed and enriched in the direction of including financial frictions that play a prominent role. Macroeconomists are, perhaps painfully so, aware that the next recession will rarely have the same

characteristics as the most recent one, and as a result their theories grow richer and more complex, rather than themselves undergoing cyclical fluctuations.[3]

1.1.10 Global interactions

The Great Recession was a **global** financial crisis: stresses originating in U.S. housing and banking spread to other countries through funding markets, cross-border bank exposures, and the collapse in trade and trade credit, synchronizing recessions worldwide. This experience underscored the importance of studying open-economy models, where shocks in one country (such as total factor productivity disturbances) can propagate to other countries through shifts in capital flows and the resulting movements in relative prices (e.g., terms of trade and real exchange rates), with the strength of spillovers shaped by the degrees of international risk sharing and exposure in balance sheets. The European sovereign-debt crisis in 2011-12 was triggered, in part, by the Great Recession, which exposed fragilities in the euro-area financial system. Concerns about debt sustainability pushed spreads sharply higher in countries such as Greece and Cyprus, which eventually had to restructure their debt. Fears of sovereign default extended to other European countries, such as Ireland, Portugal, and Spain who also saw their spreads raise significantly. This episode brought sovereign-default models— originally developed to study emerging countries during the sovereign debt crises in Latin America during the 1980s— back at the center stage. Macroeconomists have since spent significant effort in understanding the international transmission of business cycles and how borrowing, default risk, and default interact with fiscal policy and the business cycle. The post-pandemic rise in public debt ratios across developed and emerging countries has renewed (and keeps salient) the importance of these topics.

1.1.11 Climate change and energy economics

The intersection between macroeconomics and environmental economics was close to empty until it became clear toward the end of the 20th century that **climate change**, at least in important part caused by human emission of carbon dioxide into the environment (primarily by burning fossil fuels like oil, natural gas, and coal), was a potentially critical threat to our welfare. Increasingly, many economists have become engaged in climate research and contributed importantly to our understanding of how climate change interacts with economics. Macroeconomists have helped in damage measurement by studying aggregates and how they react to weather as well as climate. But macroeconomists have also contributed by constructing global economic models aimed at *integrated assessment*: examining how different economic policies would influence the world's market economies and jointly determine climate and economic outcomes, hence providing advice for policymakers. This endeavor has led to an upsurge in quantitatively oriented modeling of global interactions between the macroeconomy and the climate.

The focus on fossil fuels also directs the attention of macroeconomists to natural-resource and energy economics, which attracted attention already in the 1970s as the oil shocks hit. The questions now are similar to what they used to be, and they have been underscored

[3]Voices were certainly raised suggesting that a return to classic Keynesian theory was called for.

by recent events such as the war in Ukraine. In short: **what is the nature of energy supply and how does the economy react to shortages in it; and what is the potential for technological change in this area?** The climate-energy area, along with communication of the research results to policymakers, can turn out to be of particularly high value, given the large global interest in it. Climate science and research on energy technology are obviously crucial inputs, but policy is also needed to steer individuals and markets in useful directions. How this is best done is a matter of understanding economic decisions and market interactions: it is a question for economists.

1.1.12 Where do we stand?

Clearly, our economies are constantly evolving as a result of a number of societal changes, including technological developments and policy reforms. With these changes, we have indicated how macroeconomics has changed course, sometimes abruptly and sometimes merely by expanding on existing frameworks. We currently have a body of knowledge that allows for a more nuanced understanding of macroeconomic events and policies, and the macroeconomic models used in practice are accordingly much richer than in the past.

Do we lack sufficient self-criticism, however? One regularly hears arguments that macroeconomics never really admits that it is wrong, nor that it recognizes that it needs to change course. In concrete terms, can we really say that we are in a better position today to meet the next major macroeconomic challenge? Our perception, first, is that macroeconomists do admit mistakes, as indicated by the number changes in our thinking that have been described above. On some occasions, our theories simply have not incorporated all relevant features—this would be "our" mistakes—and as a result we have tried to build these features in as swiftly as possible. On other occasions, though, we have simply been surprised by events that did not have economic origins and yet necessarily generated economic downturns that, once we were informed of the "shock," we could understand with existing models.

Our own firm belief is in fact instead that, guided by research, macroeconomic policy has been increasingly successful over time. Not all recessions are alike, but they are not all distinct either, and lessons from one will typically be useful in the future too. In particular, we count the responses to the Great Recession and to the 2020 pandemic recession, where fiscal and monetary policy were used actively, as having benefited in major ways from macroeconomic research. At the same time, of course, not all governments acted alike and there always remain differences in views on policy, especially since strong views on economic policy tend to be linked to strong political views.

Thus, as different shocks hit our economies, we do not cycle back and forth between models, each model emphasizing one type of shock and how to respond to it. Rather, we strive to combine insights as they arrive and try to isolate how they add to, rather than erase, our previous understanding of the economy. For illustration, consider Keynes's core insights: they were entirely new and crucial for building an understanding of how stabilization policy could be usefully conducted, and although the 1970s saw a definite break in the foundational elements underlying macroeconomic models and a temporary return to very stylized models, the Keynesian insights have since been added back into the newer models. These models are simply more sophisticated today than before and are more clear on the circumstances under which Keynes's insights can be applied. The models keep developing; for example,

the reliance on rational expectations may develop, as we obtain more data on how forecasts are actually made. Macroeconomists appear to be in agreement that frictions in financial markets can be critical and even central in explaining some recessions, but how to identify the key frictions and prevent them from playing out is still an open question; clearly, a prohibition of all loans would by definition have prevented the mortgage market from causing problems, but very clearly such restrictions are highly undesirable. Thus, research on this issue today is trying to identify how we can reach a balance between stability and business-as-usual market efficiency. Many challenges remain in macroeconomic research but we are nevertheless optimistic that there will be fewer and fewer oopses in the future.

Finally, the construction of rich and complex models is of course not an end in itself and especially for communication and in teaching—even at the graduate level—it is important to simplify and abstract from many of the complexities. Therefore, IS-LM models can still be useful in building an understanding of how the macroeconomy works, as can real business cycle models and simple models of debt crises. But beliefs that either of these models is sufficient has been proven wrong many times over.

1.2 Looking ahead

This introductory chapter has sampled a number of important topics addressed by macroeconomists over the course of the last century. Many topics have been left largely without comments, such as trade liberalization and immigration. This is not to suggest that they are any less important: they remain very active research areas, some overlapping with further sub-disciplines of economics such as international trade—and the main focus here has instead been to illustrate the large variety of topics and methods.

The development of rich and complex models means that macroeconomics is not becoming easier. This textbook is a living proof of this statement: although it makes a major effort to mix data and historical episodes with theory, it does require new students of this area to make serious investments in methods. In particular, the switch toward microeconomics-based theory, with an accompanying aim to match the main historical facts—*quantitative theory*—motivates many of the early chapters. The belief on which this text is based is that this material is here to stay. One possibility is that the theory will be supplemented with elements of behavioral economics, but there is little consensus yet on which features are key. This regards both how we view the choices made by consumers and firms and how they form expectations. For now, full rational optimization and expectations are viewed to be a very reasonable starting point, and the insights from investments in these methods will also highly likely be relevant as behavioral elements may be added. Thus, we try to view the methods parts as fun, because they are, though they are never there for their own sake: their only aim really is to help us understand the macroeconomy. This is the nature of macroeconomics; it is challenging, but it is engaging.

Next, in Chapter 2, we dive into the macroeconomic data and, bit by bit, introduce Solow's way to make sense of this data: macroeconomic aggregates are generated by the neoclassical growth framework. This framework is the core setting used in macroeconomics. The framework is not an arbitrary one: as the chapter explains in some detail, it is instead precisely motivated by a need to square our theory with some striking, long-run facts that are

very hard, if not impossible, to explain without this theory. The chapter also moves beyond Solow's treatment by arguing that some parameters he treated as exogenous constants—saving rates and hours worked—are better described as conscious choices of households in a market environment. The chapter concludes with a preview of the remainder of the text, emphasizing that virtually every chapter thereafter, dealing with the main, applied topics in macro (growth, business cycles, asset prices, labor markets, etc.), build directly on the market version of the neoclassical growth model.