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Review Article: Perspectives on the Future of Asset Pricing

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The field of asset pricing is a rich and diverse discipline that has contributed to many areas of discourse, including those of fundamental importance to policy makers, investors, and households.[1] As we look ahead during a time

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[1] The introduction is by Ralph S.J. Koijen and Sydney C. Ludvigson.

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of substantial economic and political change, it is apparent that society faces many pressing questions, both new and old, that the field is uniquely suited to informing.

To contribute to this conversation, the NBER Asset Pricing program convened a panel discussion on "Perspectives on the Future of Asset Pricing" at its November 8, 2019, meeting that took place at Stanford University. The objective of the panel was to identify some of the important questions the field could productively address in the next five to 10 years. The panelists, consisting of experts in several subfields of asset pricing, were invited to share their views on these questions with an eye toward innovative research topics that are ripe for exploring, and the metrics the field could be using to gauge progress.

This article summarizes these views. The list of topics covered by the panelists is by no means exhaustive. We hope that this article shall nevertheless serve as a productive conduit for identifying some key questions for investigation and generating a concerted research effort toward answering them.

1. Empirically Grounded Models of Subjective Beliefs

Beliefs are central to asset pricing.[2] Asset prices are forward-looking, and essentially any asset-pricing model implies that investors price assets based on their beliefs about the joint distribution of some stochastic discount factor (SDF) M_{t+1} and payoffs X_{t+1}. An observer outside the field of asset pricing might therefore guess that a major part of the research efforts in asset pricing are devoted to understanding how investors form beliefs. This is, at least so far, not the case.

The vast majority of theoretical and empirical work in asset pricing is based on the rational expectations (RE) paradigm. Under RE, as in Lucas (1978), investors are assumed to know the economy's underlying model and the model parameters, and to forecast rationally.

Within the RE paradigm, there is no role for the study of beliefs: theoretically, beliefs are implied by the model; empirically, an econometrician can recover investor beliefs from the large-sample empirical distribution of M_{t+1} and X_{t+1}.

RE-based approaches have been useful to establish a benchmark, but asset prices have not yielded easily to RE-based explanations. Seeing the increasingly complicated dynamics in preferences and endowment processes researchers use to reverse-engineer better-fitting RE models, it is natural to wonder whether more progress could be made by treating belief dynamics as an object of theoretical and empirical study.

I propose that such a research program should be organized around the following three principles:

[2] This subsection is the perspective of Stefan Nagel.

- Research focus should be on motivating, building, calibrating, and estimating models with non-RE beliefs rather than on merely rejecting RE models. To make further progress, we need structural models of belief dynamics that can compete with RE models in explaining asset prices and empirically observed beliefs.
- Deviating from RE does not necessarily imply assuming irrationality. For example, models of Bayesian learning relax the RE assumption that agents know the model of the world and its parameter values, while retaining the rational forecasting assumption. Exploration of cognitive limitations, bounded rationality, and heuristics that relax the rational forecasting assumption may have promising insights to offer as well, but even models of rational learning can produce asset-price properties that are quite different from those in an RE setting.[3]
- Belief dynamics should be disciplined with data on beliefs and micro decisions. While reverse-engineering of preferences and technology to fit asset prices is common in the literature, I would argue that we should not follow this approach with beliefs. Taking beliefs seriously as an object of scientific study also means bringing in empirical data that helps pin down their dynamics.

In line with these principles, a number of areas seem promising for future research:

1.1 Belief measurement

The availability of beliefs data has improved substantially in recent years, but for beliefs data to become a standard ingredient of asset-pricing research, further progress on measurement is necessary.

So far we do not have a good understanding of investor expectations of firm cash flows. Existing work on expectations in asset pricing has often focused on return expectations, but return expectations alone, especially ones limited to relatively short forecast horizons, do not provide a complete picture of how beliefs dynamics explain variation in price levels. Forecasts of earnings and dividends by analysts, used in De la O and Myers (2019), and by CFOs in the Graham and Harvey (2011) survey are a start, but there is more to be done.

Collecting more data on long-run expectations would be useful. Much of the currently available expectations data is focused on short forecast horizons such as one year. Asset prices, however, depend on expectations over much longer horizons.

In addition to perceived first moments, investors' subjective perception of risk are also of obvious relevance to asset pricing.[4] Data on beliefs about the

[3] See, e.g., Timmermann (1993), Lewellen and Shanken (2002), Collin-Dufresne et al. (2016).

[4] Lochstoer and Muir (2019) show that subjective volatility perceptions can explain a number of asset pricing puzzles.

perceived downside tails of the distribution would be particularly interesting. Since crashes and disasters are infrequent, objective historical data does little to pin down these tails, leaving lots of room for subjective judgements. Eliciting beliefs about the shape of distributions is a challenging problem, but further research on belief elicitation methods may bring progress in this area, too (Manski, 2018).

Finally, in many asset-pricing applications, we are interested in dynamics of beliefs at frequencies of the business cycle, or even lower. This means that we need long time series. The time series available in survey data have lengthened substantially, but there are still potential benefits from innovations that can help to extend beliefs data backwards in time, for example, with proxies constructed from textual analysis of media, somewhat akin to what Manela and Moreira (2017) have done to extend the VIX index.

1.2 Beliefs and actions

If a respondent in a survey states a belief, this does not necessarily mean that the respondent is ready to act in accordance with this stated belief. In addition to a decision-relevant signal, stated beliefs likely contain measurement noise. For example, it is unlikely that respondents deliberate as carefully when stating beliefs as they would if they actually had to take an action. Moreover, even if stated beliefs truly reflect respondents' perceptions, actual or cognitive costs of taking an action may prevent respondents from perfectly aligning their choices with these beliefs. To sort out these issues, more research on the connection of beliefs and actions is needed.[5]

For asset pricing, we also need to understand the properties of this measurement error when we aggregate across respondents. If measurement error averages out within the population, or within demographic groups, then matching asset-pricing models with beliefs moments based on such aggregates may be fine, even if the links between stated beliefs and actions are distorted by measurement error at the individual level. To the extent that more sophisticated agents play a bigger role in financial markets, how the belief-action relationship varies with sophistication is an important issue as well.[6]

Another important question to sort out is whose beliefs matter for pricing. Individual investors' beliefs can differ from those of professional investors. The relative importance of their beliefs in influencing asset prices likely differs by aggregation level: For allocation decisions at the asset class level (e.g. stocks vs. bonds), it seems likely that individuals exert substantial influence because the investment products they choose from often have predetermined allocations to an asset class; at the individual stock level, fund managers have discretion; at the investment-style level (e.g., small vs. large stocks) there is probably a

[5] Giglio et al. (2019) is a recent example of work that looks at this question.

[6] See, e.g., D'Acunto et al. (2019) for recent research of this kind.

mix of predetermined choices by individuals and managerial discretion. Sorting this out empirically would also help in linking belief-based approaches with a demand-system analysis as in Koijen and Yogo (2019).

1.3 Modeling belief formation

Models of investor belief dynamics need to take a stand on the sources of information that investors rely on when they form their beliefs and how they digest this information to produce forecasts. Two questions in this regard seem particularly interesting.

How do investors form beliefs when faced with high-dimensional prediction problems? Existing asset-pricing models with parameter learning typically consider settings with a small number of predictor variables. Reality, however, looks different. For example, to value stocks, investors must forecast cash flows. They observe a vast number of potential predictor variables, but they do not know the precise functional relationship between predictors and future cash flows and need to learn it from observed data. In a simple linear setting with homogeneous investors, Martin and Nagel (2019) show that this can give rise to return predictability and a "factor zoo." Further efforts to close the gap between the simplistic environments investors face in asset-pricing models and the messy real world seem necessary.

The second question concerns the role of memory. Data can shape beliefs only if it is remembered. In theory, one could imagine a Bayesian learner that takes into account "all available" history when learning about pricing-relevant stochastic processes. But when mapping these models into the real world, it is not clear what "all available" means. Some implementations of learning models set time zero to 1926, because this is where the CRSP database starts, but this is obviously not the true starting point of investors' learning process. Moreover, there are reasons to expect that memory could be limited. More research, both empirically and theoretically, is needed to better understand investors' formation of memory, including those of institutions (e.g., through maintenance of data sets or establishment of decision rules).[7]

1.4 Beyond asset pricing: Macro-finance

The drivers of stock price dynamics emphasized in asset pricing research are largely disconnected from the drivers of the business cycle that macroeconomists focus on (see, e.g., Cochrane 2017). This question should be revisited through the lens of models with non-RE belief dynamics. Shocks to beliefs are potential source of links between asset prices and macro quantities. Exactly how such links could play out is an open question.[8]

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7 Collin-Dufresne et al. (2017), Nagel and Xu (2019), and Wachter and Kahana (2019) are recent examples of such research.

8 As an example, work by Kozlowski et al. (2020) suggests that beliefs about disasters could play a role.

Beliefs effects could operate in ways that are quite different from time-varying preferences that macro and asset-pricing research has already explored in various ways. For example, belief effects can be specific to technologies or markets. An individual could be optimistic about the housing market but, at the same time, pessimistic about the stock market. Beliefs data will be important to sort out the commonalities and differences between different sectors and markets.

Interactions of beliefs with frictions are potentially interesting. For example, belief heterogeneity can interact with frictions in a way that amplifies shocks (Caballero and Simsek (2020)). The housing market seems to be a particularly interesting area to explore these types of mechanisms, as it features substantial frictions and plays a big role in the macroeconomy.

1.5 Conclusion

Asset prices express investors' beliefs about the future. Our understanding of how investors form these beliefs, how they evolve over time, and how we can measure them is still limited. Empirically grounded research on investor beliefs holds promise to unlock some of the mysteries of asset pricing.

2. Expectation Formation in Asset Pricing

The conventional agenda in the asset pricing literature studies quantitative rational expectation models.[9] This approach is particularly well suited for the study of recurring patterns, such as the comovement of price-dividend ratios on stocks with the business cycle or the seasonality in the housing market during a calendar year. (Volume and prices are above trend during the summer, while activity in housing markets slows down in the winter.) In rational expectation models, the expectations of agents reflect these recurring patterns and are consistent with the equilibrium dynamics of the model. The model is successful if the distributions of equilibrium prices and quantities are consistent with those in the data.

An advantage of this approach is that agents' expectations do not introduce free parameters. Rational expectations impose cross-equation restrictions on agents' expectations and equilibrium dynamics that constrain these parameters to be the same. This approach imposes a welcome discipline on the model if there are no data on expectations. By design, the approach assumes that all agents have the same expectations. To study differences in expectations, a researcher has to specify the source of information that only some agents may receive, while others do not.

Recent years have witnessed a massive effort to collect expectational data. These new data enable researchers to be more agnostic about how agents

[9] This subsection is the perspective of Monika Piazzesi.

arrive at their expectations. It is now possible to discipline expectations with direct observations on households and firms. More and more surveys that ask respondents about their expectations also ask them about their characteristics (e.g., household or firm age, income, or sales) and choices (e.g., investments). These data allow researchers to study the joint distribution of expectations, characteristics, and choices. Now a model is successful if it can match the observed joint distribution in the data.

Freeing up expectations is especially appealing to study unique episodes that are associated with structural change. In these instances, it is often not clear how agents were forming expectations at the time. For example, what explains postwar house price booms? Two major boom-bust episodes stand out in the United States, because they coincide with booms in other countries (e.g., chapter 4.5 in Piazzesi and Schneider 2016). The first boom occurred during the late 1970s and early 1980s, while the second boom occurred in the early 2000s; both episodes had unique features. An important contributor to the first boom was the Great Inflation. How did households form expectations about future inflation during this unique event? Low interest rates during the second boom made it cheap for households to borrow and increased the value of houses, computed as the present value of a stream of future housing services. When house prices collapsed in 2007, interest rates came down further and remained close to zero. Did households during the boom foresee the low rates after the collapse? Did home buyers at the peak of the boom expect house prices to further appreciate, or were they aware that house prices were about to decline? What did renters expect during these years? Again, surveys help us understand households' expectations and actions during this unique episode. It is difficult to think about these house price booms as recurring patterns.

2.1 Big data collection efforts

Central banks have recently pioneered massive data collection efforts to improve the foundations of their economic models and ultimately their conduct of monetary policy. Many private companies, such as Vanguard, contribute to this effort because they want to better understand their clients. The surveys ask individual households or firms about their expectations for the future. Some surveys ask respondents to forecast aggregate variables: macro-economic indicators (e.g., inflation, GDP growth) or financial variables (e.g., stock returns, bond returns). Other questions ask about individual-specific variables such as income. More and more, surveys ask the same respondents about their expectations and actual choices. For example, households are asked about their stock return forecasts and stock holdings. Other surveys ask firms about their current sales and sales forecasts.

Examples of such surveys include the European Community Household Panel by the European Central Bank and its member banks, which asks a panel of households about their income and living conditions. There are modules in the survey that ask about household expectations. Since 2011, the

Bundesbank has been conducting the Panel of Household Finances, which asks households about their expectations and their choices. Since 2013, the Federal Reserve Bank of New York has the Survey of Consumer Expectations, and the Federal Reserve Board has the Survey of Household Economics and Decision Making. The Bank of Canada has conducted the Canadian Survey of Consumer Expectations since 2015.

There has been considerable progress in how to frame the survey questions in a way that enables people without formal training in statistics to express their perceived uncertainty about these forecasts. This progress is often made by academics who are directly involved in the survey. For example, Bachmann et al. (2019) ask German firms about their future sales growth in the Ifo Business Tendency Survey. To get a measure of the uncertainty that firms perceive, the researchers formulate a survey question that asks firms to provide a best- and worst-case scenario for their future sales growth. The span between these scenarios provides a useful measure of uncertainty, since most of these firms routinely use scenario analysis. Bachmann et al. (2020) document that firms find it difficult to express their uncertainty with a probability distribution. Many other surveys also involve researchers directly. For example, the Bundesbank solicits questions from academics for its Online Survey of Consumer Expectations. The Atlanta Fed Survey of Business Uncertainty involves researchers in its survey design. Companies like Vanguard allow researchers to ask questions for a subset of their investors.

2.2 How do survey expectations compare with rational expectations from conventional models?

The conventional agenda has worked hard to come up with models that are successful at generating investor expectations that are consistent with predictability regressions for asset returns. In the data, high ratios of asset valuations relative to fundamentals tend to be followed by low returns on the asset compared with the risk-free rate. For stocks and housing, regressions of excess returns over the next, say, five years on the current price-dividend or price-rent ratio have a negative slope coefficient that is statistically significant. For bonds, the regression is on the difference between the price on a long bond compared with a short bond. Expectations that capture this pattern describe investors who have low return expectations in booms. The reason why assets are highly valued despite this pessimistic outlook is that investors may be less risk averse in asset booms. Alternatively, investors may perceive less risk in booms.

Survey evidence challenges this view. A growing number of papers documents high return expectations in booms. For stocks, Greenwood and Shleifer (2014) provide evidence that investors predict high excess returns on stocks during booms. De la O and Myers (2019) show that high price-dividend ratios are associated with high cash flow expectations in surveys, while expected returns do not change that much over time. In bond markets, Piazzesi et al.

(2018) document that forecast errors can account for a substantial component of cyclical movements in bond risk premia. During the postwar period, the Great Inflation is the one episode in which risk premia on long nominal bonds were high.

Similarly, for housing, Case and Shiller (2003) document that households that bought a house at the peak of the housing boom in 2003 were expecting double-digit appreciation rates for houses not only over the next year, but over the next decade. Piazzesi and Schneider (2009) document that there is only a small fraction of households (roughly 10% of all households) that believed it was a good time to buy a house during the early phase of the housing boom (during the years 2000–2003). This fraction doubles during the years 2003–2006. Since there are few housing transactions overall — less than 10% of the housing stock turns over in any given year — a boom in house prices is easily supported by a small fraction of households that are optimistic. The Case-Shiller evidence suggests that these optimistic households select themselves into these few transactions and sustain high valuations.

The conventional wisdom is still dominant. Research that relies on survey answers has to argue that they provide direct evidence about expectations. A question is whether survey respondents are the right people to ask about their expectations — they may not be marginal investors. Some surveys address this issue by focusing on people who recently bought the asset, as does the Case-Shiller survey of recent home buyers. Another question is whether the survey respondents really understand what they are being asked. There has been recent progress on this front by researchers who are involved in the survey design, as I already mentioned. Another important concern is whether survey answers reflect the career concerns of professional forecasters.[10] Finally, surveys may reflect risk-neutral forecasts. Adam et al. (2019) provide evidence against this argument for stocks. These concerns are important because they improve survey design and will lead to better survey evidence in the future.

2.3 Belief heterogeneity

Why do households have heterogeneous expectations? Some differences in beliefs can be explained with informational advantages by certain households. During the recent housing boom in Germany, for example, renters have on average higher rent and house price expectations than owners who severely under-predict these variables (Kindermann et al. 2020). This pattern is consistent with the idea that housing is a unique asset, where non-owners (renters) may have more precise signals about housing dividends (in units of numeraire consumption) than owners of the asset who consume the housing dividend but may not know how much it is worth.

[10] An attractive feature of the Survey of Professional Forecasters conducted by the Philadelphia Federal Reserve is that survey respondents are anonymous, which reduces the importance of career concerns. Bluechip survey respondents are not anonymous but are serving a wide range of clients who may be either long or short in fixed income assets, which also mitigates these concerns.

Will we be able to explain all the cross-sectional variation in household expectations? The answer to this question will likely be no. The same observable characteristics (e.g., age, income, and wealth) that have high R^2s in explaining other choices that households make (e.g., housing tenure) have rather low R^2s in explaining their expectations.

A more humble approach, which is still very interesting, is to admit that we do not know how households get to their expectations. Successful papers along these lines are Landvoigt (2017), Lenel (2018), and Giglio et al. (2019). Even with a more humble approach, we can describe clusters of people (e.g., Piazzesi and Schneider 2009) and study how these clusters evolve over time (e.g., Burnside et al. 2016). These approaches may help us to make progress in our understanding of volume in asset markets, which is one of the most important open issues in finance.

2.4 How to use survey beliefs in models?

One way to use survey beliefs as an input into our models is to work with a temporary equilibrium concept (for an introduction, see chapter 3.4 in Piazzesi and Schneider 2016). Suppose heterogeneous agents solve dynamic optimization problems given some expectations that may be functions of time t variables. The outcome of these optimization problems will be an excess demand system for goods and assets at time t. Equilibrium prices set this system of equations to zero at time t.

A rational expectations equilibrium is a special case of a temporary equilibrium, that requires the expectations to be consistent with equilibrium dynamics. An alternative approach is to use survey forecasts to discipline expectations. This approach deals with unique episodes, which are reflected in the survey answers. A successful model then matches equilibrium prices and quantities as well as expectational data. An example of such an approach is Landvoigt et al. (2015), who study the role of credit conditions and expectations during the housing boom of the early 2000s. Another is Leombroni et al. (2020), who study the role of heterogeneous inflation expectations and inflation uncertainty for house prices and stock prices during the Great Inflation.

3. Macro and Monetary Economics Connections

The field of finance and asset pricing has the potential to go through a transformational period by enriching other fields of economics and adopting new solution techniques.[11] Four important areas come to mind. First, asset pricing and financial frictions have become the centerpiece of modern monetary and macro economics. Central banks are key drivers of asset prices. This is especially true after the global financial crisis and during the COVID-19

[11] This subsection is the perspective of Markus Brunnermeier.

global pandemic. We have witnessed unprecedented central bank activism: Most central banks heavily intervened in asset markets. Nowadays they not only determine the short-term interest rates but also impact many asset prices via quantitative easing programs, active yield curve management, funding for lending programs, and repo programs. Central banks are also not shy to conduct large-scale experiments with the economy, creating an "El Dorado" for empirical researchers. In addition, many interest rates turned negative calling for new fixed income models. Second, safe assets are the focal point of recent debate to understand the low interest rate puzzle and sudden flight-to-safety phenomenon. Safe is not necessarily the same as risk-free (or default risk-free). Third, new quantitative tools, such as neural networks and deep learning algorithms, now enable researchers to numerically solve nonlinear continuous-time macro-finance models with many state variables. These new methods allow us to solve models in which we disaggregate the financial sector and study the impact of various policies and shocks on banks, insurance companies, pension funds, and asset managers separately. Fourth, finance and money are in the middle of a technological revolution. New technology allows us to exploit big data and link various data sources. This makes digital money more attractive than physical cash and mitigates liquidity frictions. Hence, the asset feature of money has become more prominent, and many assets can gain some of the liquidity benefits of money. The main part of these remarks outlines four trends in more detail.

In New Keynesian (NK) macroeconomic models, arguably the dominant school in monetary economics (see, e.g., Woodford 2011 or Galí 2015 for nice textbooks), the key friction is price/wage stickiness. The central equation is the Euler equation, which describes the savings-consumption choice, and the most important price is the risk-free interest rate. In contrast, in macro-finance models, the focus is on financial frictions in form of borrowing frictions like in Kiyotaki and Moore (1997) or Bernanke et al. (1999) or incomplete markets like in Brunnermeier and Sannikov (2014, 2016). The latter embeds an intermediate asset pricing model in a macro setting in which resource allocation and economic growth are endogenous. The portfolio choice between a risky asset and safe asset, often in the form of money, is key. The price of risk and risk premia are at least as important as the risk-free rate. Resource allocation and the endogenous growth rate feed back into portfolio choices, the risk-free rate, endogenous volatility, and the price of risk. The term premium contains a risk premium, as do credit spreads — that is, credit spreads reflect risk attitudes as well as expected losses. The risk premium is the product of price of risk times the sum of exogenous and endogenous risk. Endogenous risk is subject to amplification and spirals and can reflect risk-on-risk-off phenomena. In short, the price of risk affects and is affected by the resource allocation and endogenous growth of the economy. All variables interact with monetary policy that tries to affect not only the risk-free rate but also risk premia. The emphasis on endogenously time-varying risk and price of risk, and the portfolio choice, is in sharp contrast to Heterogeneous Agent New Keynesian (HANK) models (Kaplan et al. 2018) in which the risk premium is either zero or constant.

Another future trend that affects asset pricing is the recognition of the special role of safe assets. Brunnermeier and Haddad (2014) stress two important characteristics of a safe asset. First, a safe asset is like a good friend, who is around when you need her. Similarly to a good friend, a safe asset is valuable and liquid whenever you need it, at a random horizon. In contrast, a risk-free asset pays off a fixed amount at a prespecified horizon. Second, there is the "safe asset tautology." A safe asset is safe because it is perceived as safe. Investors coordinate to fly into certain assets in times of crisis. This points in terms of economic modeling to settings with multiple equilibria and/or bubbles. For example, Swiss government debt is considered as a flight-to-safety asset and appreciates in crisis times, while the Swedish krona typically depreciates in value during crises. In "The I Theory of Money" models, money or government bonds are the safe asset and are a bubble.

Another trend that will change asset pricing relates to new modeling and especially numerical techniques. Neural network techniques will open up a new research avenue in macro-finance. Existing macro-finance models aim to keep the number of state variables that describe the evolution of the dynamical system low. This is especially true for macro-models with nonlinearities due to amplifications and runs since they cannot be solved simply by log-linearizing around the steady state. The limitation to a few state variables has prevented researchers from incorporating the richness of the financial intermediary sector. Typically, the financial sector is summarized by a single sector, even though we know that banks, insurance companies, asset management firms, pension funds, and so on have very different risk exposures across the various risk factors. Using novel deep learning techniques will endow researchers with the tools to fully explore the heterogeneity within the financial sector. Duarte (2018) and Lauriere et al. (2020) provide early advances in this area.

Finally, the fintech revolution will also alter asset pricing research. Big data has the potential to fundamentally reshape our economies, including financial intermediation and payment. So far, studies on payments have only played a role on the sidelines. However, with the recognition that payments deliver valuable data that can feed recommender systems and improve various scores, in particular credit scores, payments are moving to center stage. The current "banking-centric" industrial organization structure of financial activities might be replaced with a "payment-centric" structure. Platforms might be at the center rather than deposit-taking and lending banks. Social networks will play a more important role. Such a shift has important implications for money and also asset pricing. Money will become more digital. So far, bank accounts (inside money) are of course already digital. But only a part of outside money, central bank reserves, is digital, whereas cash is not. Digital money has the advantages that it can be linked to digital platforms, it can be traded automatically using smart contracts, and it is more convenient to use. Hence, as we already see in several countries, cash is losing its importance. Central banks have become increasingly concerned over the potential loss of monetary sovereignty— that is, the power to effectively conduct monetary policy. Among the three roles of money, the unit of account, store of value, and medium of exchange, ensuring that central bank-issued money remains a unit of account is essential for retaining monetary sovereignty. In models with incomplete markets, if debt is primarily denominated in the national currency, monetary policy can redistribute wealth (ex post) and be a risk-sharing tool (ex ante), as, for example in the case of the I Theory of Money. This reduces the price of risk and lowers endogenous risk. If transactions are increasingly conducted in and debt is denominated in new forms of digital currencies, for example those introduced by TechGiants, a process labeled as "digital dollarization" kicks in; see Brunnermeier et al. (2019). Central banks lose their grip on monetary policy to smooth out the business cycle, and seigniorage revenue fades away. New "Digital Currency Areas" can emerge whose borders are more governed by connections to particular platforms and data regulation rather than national boundaries. For these reasons, central banks are seriously considering introducing their own "digital cash" in the form of Central Bank Digital Currencies (CBDC). Foreseeing the transition of the financial sector is not easy, but it is likely that currencies like Bitcoin and recently Libra will serve as catalysts in the same way Napster did for the music industry about 20 years ago.

This document identifies four trends that are likely to have an impact on research in asset pricing. First, central banks have become important players in asset markets, calling for more studies in which asset prices and monetary policy interact in a meaningful way. Second, flight-to-safety phenomena during a switch from a risk-on to a risk-off mood stress the importance of studying the role of safe assets. Third, new numerical techniques based on deep-learning machine-learning algorithms allow us to solve and estimate macro-finance models that reflect the heterogeneity of the financial intermediary sector. Finally, fintech and big data put digital money and payments at center stage with the emergence of digital currency areas.

4. Macro and Monetary Drivers of Asset Prices

A long intellectual history in economics considers the state of the macroeconomy among the most important drivers of asset markets, be these stock markets, bond markets, or housing markets[12]. At the same time, vast literatures in macroeconomics have argued that the aggregate state is itself profoundly influenced by the operations of monetary authorities around the globe. Ultimately, the question of whether and to what extent fluctuations in aggregate economic activity and/or monetary policies matter for asset pricing

[12] This subsection is the perspective of Sydney C. Ludvigson.

is an empirical one; thus, addressing it requires an empirical research agenda. As we ponder the exciting paths forward for the field of asset pricing, it is worth reflecting on where we are with this agenda.

On the question of whether macroeconomic risk matters for asset pricing, the evidence is mixed. Some research has found that it does,[13] while other research has found that it does not.[14] Confronted with these conflicting findings, it may be tempting to proceed as if macroeconomic conditions are unimportant for asset pricing. And yet, the stock market appears to react strongly to macroeconomic news (e.g., Boyd et al. 2005; Ai and Bansal 2018; Baker et al. 2019), a global financial crisis from 2007 to 2009 laid bare the important feedback loops between financial markets and the real economy, and it is hard to imagine that the tremendous structural change of the past several decades—slowing growth, rising profit shares, growing inequality, low and declining real interest rates—has not affected the pricing of risky assets.

Regarding monetary policy, there is ample evidence that unanticipated actions and announcements by central banks have important consequences for long-lived asset markets.[15] But surprisingly little attention has been given to understanding how this can occur, when all available evidence suggests that monetary policy shocks have transitory effects on the economy.

4.1 What's the macroeconomy got to do with it?

There are many possible reasons why evidence cited above might be mixed: our models are gross simplifications of reality; the data are mismeasured and limited; our estimation tools are sometimes restrictive; information sets are unobserved. But one feature that is shared by all of the evidence cited earlier is their representative agent perspective, which presumes that growth in aggregate (average) consumption is an appropriate measure of systematic risk. At least when it comes to the pricing of equity, it is worth remembering how at odds this perspective is with even the most basic facts of stock market ownership. According to the Survey of Consumer Finances, just 52% of households owned equity in any amount or any form in 2016. More significantly, because stock market wealth is so heavily concentrated at the top (the top 5% of the stock wealth distribution owned 76% of the stock market in 2016), participation rates on a wealth-weighted basis are much lower than 52% and trending down since 2004. We might reasonably ask whether the representative agent framework is just too much of an abstraction.

[13] Chen et al. (1986), Lettau and Ludvigson (2001), Parker and Julliard (2004), Koijen et al. (2017), Bansal et al. (2016), and Ghosh et al. (2016).

[14] Breeden et al. (1989), Campbell and Mei (1993), Lewellen and Nagel (2006), Roussanov (2014), and Herskovic et al. (2019).

[15] Hanson and Stein (2015), Gertler and Karadi (2015), Gilchrist et al. (2015), Boyarchenko et al. (2016), Jarocinski and Karadi (2020), Cieslak and Schrimpf (2019), and Kekre and Lenel (2019).

Macro-finance trends also suggest an important role for heterogeneity. Indeed, the ratio of market equity for the corporate sector to three different measures of broad aggregate economic activity has trended up over time and is at or near its postwar high by the end of 2017. By contrast, the ratio of market equity to after-tax profits (earnings) for the sector is not trending up and is not near a postwar high. (See Greenwald et al. 2019 for plots.)

One response to these facts is to revisit an earlier literature that stressed the importance for equity pricing of limited stock market participation and heterogeneity (Mankiw and Zeldes 1991; Vissing-Jørgensen 2002; Aït-Sahalia et al. 2004; Guvenen 2009; Malloy et al. 2009). Lettau et al. (2019) (LLM), and Greenwald et al. (2019) (GLL) do so by studying the empirical implications of a heterogeneous agent model characterized by two types of agents and imperfect risk sharing between them: wealth is concentrated in the hands of a few investors, or "shareholders," while most households are "workers" who finance consumption primarily out of wages and salaries. In contrast to the earlier limited participation/heterogenous agent literature, the results in LLM and GLL suggest the relevance of frameworks in which investors are concerned about shocks that have opposite effects on labor compensation and shareholder payout. Such redistributive shocks play no role in the traditional limited participation/heterogeneous agent literature.

As regards the relevance of representative agent frameworks, LLM find that exposure to growth in the capital share of national income is an important determinant of return premia in the cross-section, while, conditional on this, exposure to aggregate consumption growth is not. GLL focus on understanding the factors that drive the real (adjusted for inflation) level of the stock market over time. During the past 30 years, a time when the market grew precipitously, GLL find that the most important driver of the market has been a string of "factor share shocks" that reallocated the rewards of production without affecting the size of those rewards. The realizations of this shock persistently reallocated rewards to shareholders and away from labor compensation, with no effect on economic growth. Economic growth contributed just 25% to the market's rise since 1989, which could be compared to the period 1952 to 1988 when economic growth powered the stock market, accounting for more than 100% of its increase. But that 37-year period created less than half the equity wealth generated over the 30 years since 1989. These findings suggest not that the macroeconomy is irrelevant for the stock market, but that distributional shocks may be more imporant than aggregate ones.

Important questions remain. Why have factor shares changed so persistently? Will these trends continue? Do the reasons for the changes matter? (I suspect so.) How are these trends related to the broader trends in wealth and income inequality, in economic growth, and real interest rates?

4.2 The how, why, and whether of monetary policy

If the real values of long-term financial assets respond to the actions and announcements of central banks, the question is why? Asset pricing theories can generally rationalize such large responses only if something related to the conduct of monetary policy will have a persistent influence on real variables. Yet the notion that monetary policy could have long-lived effects on real variables is contravened by an agglomeration of foundational New Keynesian macro theories (Galí 2015), and empirical evidence appears consistent with this (Christiano et al. 2005). But if this is so, how does monetary policy influence long-lived assets?

One possibility is that some components of monetary policy do in fact have long-lasting, first-order effects on the aggregate economy, on short-term real interest rates, and on equity market return premia. Such are the implications of evidence reported in Bianchi et al. (2016) (BLL). BLL solve and estimate a novel New Keynesian framework with two key departures from the prototypical model. The first allows for changes in the conduct of monetary policy that take the form of shifts in the parameters of the nominal interest rate rule. Such changes are conceptually distinct from those generated by a monetary policy shock, an innovation in the policy rate that is uncorrelated with inflation, economic growth, and shifts in the policy rule parameters. The second allows the evolution of beliefs about long-term trend inflation to be potentially influenced by both an adaptive learning component as well as a signal about the central bank's inflation target, with the belief rule disciplined by observations on survey expectations of inflation over time.

With the estimates in hand, one may identify movements in real variables that are attributable solely to the conduct of monetary policy—that is, to regime changes in the policy rule. These estimates imply that changes in the conduct of monetary policy generate large and persistent fluctuations in the short-term real interest rate that last for decades, in contrast to monetary policy shocks, which have far more transitory effects. The reason is that expectations of inflation are found empirically to be highly adaptive, and as a consequence, the central bank must spend a long time "convincing" households that the policy rule has changed. One interpretation of the evidence on central bank announcements is that these announcements are, in part, noisy signals about the possibility of a regime change in the conduct of monetary policy.

This evidence also speaks to the question of why real interest rates have been declining for decades. Specifically, almost all of the downward drift in the real interest rate since 1980 can be explained by regime changes in the conduct of monetary policy. This happens because the policy rule parameters exhibit a decisive shift toward more hawkish values around the time of Paul Volcker's appointment to the Federal Reserve, but then exhibit an equally decisive shift back to more dovish values in the aftermath of the near collapse of Long Term Capital Management, the tech bust in the stock market, and the 9/11 terrorist attacks. The conduct of monetary policy has remained dovish since, with the exception of a brief interlude from 2006:Q2 to 2008:Q2. Finally, shifts to a more dovish policy rule are associated with declining equity return premia, consistent with a "reach for yield" in equity markets.

As earlier, important unanswered questions remain. Why does the central bank change the conduct of monetary policy in the first place? One possibility is that it does so in part in reaction to markets (Cochrane and Piazzesi 2002, Cieslak and Vissing-Jørgensen 2017), leaving us in a circuitous loop. Why is a more dovish monetary policy associated with a decline in equity return premia? The BLL model is silent on the mechanisms that could explain their finding in this regard. As a start, the literature could look to recent intermediary-based frameworks with a banking sector (Drechsler et al. 2018, Piazzesi and Schneider 2015, Piazzesi et al. 2018). But we must keep in mind that equities are not the heavily intermediated asset class for which reach-for-yield-type phenomena are typically documented. On the contrary, a significant fraction of the equity market is held by wealthy households and retail investors. To fully understand these findings, we must ultimately account for their role too, whatever that may be.

5. Intermediary Asset Pricing and Beyond

Most capital invested in financial markets flows through the hands of intermediaries.[16] While there is little disagreement that intermediation frictions have some impact on asset prices,[17] and perhaps in particular during times of financial stress, it remains unclear how much various agency, behavioral, and regulatory frictions matter quantitatively.

Recognizing the potential importance of institutional investors, and motivated by recent asset pricing theories featuring intermediaries, a vibrant empirical literature emerged that tests the Euler condition of a particular group of intermediaries using an empirical proxy for their marginal value of wealth, such as the leverage of broker-dealers.[18]

However, by testing the Euler equation of a particular group of investors, we can at best establish that their asset demand curve is correctly specified, but not their importance for asset prices. For instance, we do not learn how asset prices would change if we were to shock the leverage of broker-dealers. To make progress on the central question of how much intermediaries matter for asset prices, we need to impose market clearing and understand the asset demand curves of all investors, that is, the asset demand system.

The modern asset demand system consists of households allocating capital to various intermediaries, such as mutual funds, pension funds, and insurance companies and to financial markets directly. Likewise, intermediaries invest in other intermediaries (for instance, pension funds invest in mutual funds) and

[16] This subsection is the perspective of Ralph S.J. Koijen.

[17] The recent work on covered interest parity deviations provides an example (Du et al., 2018).

[18] See, for instance, He and Krishnamurthy (2013), Adrien et al. (2014), and He et al. (2016).

allocate capital directly. An important goal of asset pricing is to understand investors' capital allocation decisions, that is, the asset demand curves of households and intermediaries.

5.1 Intermediary asset pricing and beyond: A demand system approach

To estimate models and to test theories of the asset demand system, it is natural to use data on portfolio holdings. This modeling approach to asset pricing and macroeconomics has its roots in the 1960s and 1970s (see, for instance, the work by Brainard and Tobin 1968), and has been revived recently by Koijen and Yogo (2019) (KY19).

A central question is how investors' demand responds to price changes and to changes in asset characteristics, and how investors substitute across various assets and asset classes. For instance, if an intermediary is forced to liquidate some of its holdings due to a binding constraint, we need to know how much prices have to fall for other intermediaries and households to step in to ensure that markets clear.

Two major obstacles in the earlier asset demand literature that resulted in its long period of hibernation were limited data on portfolio holdings as well a lack of instruments to credibly estimate demand elasticities and cross-elasticities.

The first obstacle has been resolved with the improved disclosure of portfolio holdings by institutions over time in many countries, such as, for instance, the 13F filings in the case of U.S. equities. A quick look at these data reveals several basic facts, as documented in KY19, that appear puzzling in the context of modern portfolio theory. First, institutions hold relatively few stocks. The median institution holds 67 stocks in the period from 2015 to 2017. Second, these choice sets are quite persistent over time, even as prices and asset characteristics change. Third, investors' portfolio holdings, across stocks, are not well explained by standard characteristics that capture risk and expected returns. The residuals, labeled latent demand, are important drivers of prices[19], and changes in latent demand are important drivers of returns.

To address the second obstacle, we need an instrumental variable. While the Euler equation approach allowed the asset pricing literature to sidestep thorny identification questions, this is no longer possible if one is interested in estimating the demand system. The identification challenge is no different than in the fields of industrial organization or macro-economics.[20] KY19 propose to exploit the exogenous variation in investment mandates to isolate an exogenous component of demand, but it may be possible to construct other instruments. Identifying demand elasticities is a central goal in this literature.

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[19] Koijen et al. (2019) study how much the demand of various investors, differentiated by type, size, and activeness, matters for equity valuations and long-horizon expected returns.

[20] For recent advances on identification in macroeconomics, see Nakamura and Steinsson (2018) and Gabaix and Koijen (2020a).

By taking a demand system perspective to asset pricing, a coherent research agenda emerges. For empiricists, the goal is to credibly estimate demand curves for different investors and to uncover which investor characteristics matter, such as institutional type, size, funding structure, regulatory environment, agency frictions, and informational differences. In estimating demand, it is important to explain both the extensive (that is, explaining the sparse and persistent choice sets of investors) and intensive margin (that is, the determinants of latent demand). Existing theories suggest that latent demand may be related to heterogeneity in beliefs or constraints, and it may be interesting to explore whether observable measures of beliefs (such as those from analysts or surveys) or constraints can explain latent demand.

In terms of asset pricing theory, an important avenue for future research is to develop models that explain which agency, behavioral, or regulatory frictions may give rise to sparse portfolios, low elasticities of demand, and volatile latent demand. By taking a structural approach, portfolio holdings can also be used to directly test these theories and to quantify the importance of various frictions. Part of the research agenda can be decentralized by studying a group of intermediaries in isolation, such as mutual funds or pension funds, if more granular data are available.

In summary, a successful asset pricing model must explain not only prices, but both prices and quantities, including portfolio holdings and flows,[21] as is common practice almost anywhere else in economics. Interestingly, the recent work on demand systems suggests that investors do not behave as our models suggest, and understanding the quantitative importance of such deviations may deliver valuable insights to improve our asset pricing theories. Moreover, by understanding investors' demand, asset pricing becomes more measurable and tangible, and we can hopefully reduce the "dark matter" in modern asset pricing theories (Chen et al., 2019). Instead of abstractly referring to "arbitrageurs," "intermediaries," and "noise traders" in our theories, we actually know who they are, what their asset demand curves look like, how large they are, and what their contribution is to fluctuations in asset prices.

5.2 Broader implications

The benefits of developing an asset pricing model that is consistent with prices and quantities extends beyond the academic curiosity of asset pricing researchers. Indeed, many of the salient policy and regulatory questions involve quantities: What is the impact of large-scale asset purchases by central banks? What would happen to credit spreads if a large fraction of BBB bonds are downgraded? What is the impact of growing environmental, social, and governance (ESG) mandates on asset prices? What is the impact of changing the risk regulation of banks or insurance companies? The recent COVID-19

[21] See Gabaix and Koijen (2020b) for a dynamic model of flows, quantities, and asset prices to understand the volatility of movements in the aggregate stock market.

crisis has highlighted once more the importance of being able to answer these questions quantitatively.

Understanding the asset demand system is essential to provide credible answers to these questions. Elasticities and cross-elasticities are often not targeted directly in modern asset pricing models, yet these models are used to address these questions involving large changes in portfolio holdings.

Furthermore, the asset demand of investors depends on firms' characteristics such as payout policy, leverage, investment and innovation policies, and profitability as they capture growth expectations and the riskiness of future cash flows. By combining models of the asset demand system with models of corporate decision making,[22] we obtain an integrated model of asset pricing and corporate finance that should target to explain asset prices, investors' portfolio holdings, macro quantities, and firms' corporate policies.[23]

Obviously, this research agenda using asset demand systems only just (re)started. But given the wealth of data on portfolio holdings that is available across countries and asset classes, there is a lot of scope to make progress on this key question in asset pricing using a demand system approach.

6. Intermediary Asset Pricing: Assessment and Future Directions

Intermediary asset pricing (IAP) seeks to understand the role of financial intermediaries in explaining fluctuations in asset prices.[24] It shifts the focus from a household's Euler equation, as in consumption-based approaches to asset pricing, to the pricing condition of a trader in a financial intermediary. In so doing, IAP elevates factors such as regulatory and corporate financing considerations that affect financial intermediaries. The big questions in this research agenda are: How much do intermediaries matter for asset prices? In which markets are these effects most pronounced? In which states of the world are the effects most pronounced? What are the central underlying factors driving intermediaries' effects on asset prices, and how do they vary across types of intermediaries?

IAP should be seen as a branch of heterogeneous agent approaches to asset pricing (Constantinides and Duffie 1996; Heaton and Lucas 1996). In these models, all households are on their consumption Euler equations. However, households differ in their preferences and endowment risks. As a result, factors

[22] A complementary literature develops heterogeneous agent asset pricing models with both an intermediary and a household sector as well as various corporate finance policies; see, for instance, Elenev et al. (2018). Due to computational limitations, such models can currently only handle a limited amount of heterogeneity, a small number of assets, and the models are calibrated rather than estimated. However, this literature is developing rapidly, and advances in machine learning may enable researchers to estimate larger-scale models in the near future.

[23] See, for instance, Baker and Wurgler (2004).

[24] This subsection is the perspective of Arvind Krishnamurthy.

such as the cross-sectional distribution of household income shocks and the wealth distribution drive asset market returns.

In IAP, the financial investments of some households are directed through intermediaries into asset markets. The trader at the intermediary is on her investment Euler equation, while the household who delegates investment to this trader may or may not share this Euler equation. Other households that directly invest in asset markets are on their Euler equations. The action in IAP theory is about the wedge between the Euler equations of the household that delegates and the trader at the intermediary.

Let me turn to corporate finance. A financial intermediary is a firm, with decisions made by the workers (management, traders, etc.) at the firm, accountable to the firm's shareholders, and raising financing from equity and debt holders. An additional stakeholder, the government, looms large and affects decisions in many financial firms.

If the Modigliani and Miller (1958) propositions apply to this firm, then the intermediary is but a veil and the IAP model collapses back to the heterogeneous agent asset pricing model that focuses on the delegating households. If, however, Modigliani-Miller fails, then the separation between ownership and control has relevance for asset prices. The content of the IAP model is in the specification of how Modigliani-Miller fails. Asset demand from intermediaries then is a function of these frictions. In general equilibrium, asset demand from intermediaries plus asset demand from the direct-investing households clear the asset market.

There have been a number of well-developed specifications that trace the failure of Modigliani-Miller, borrowing from corporate finance theory, to equilibrium asset prices. I will mention two. He and Krishnamurthy (2013) develop an agency-theoretic model where the trader at an intermediary must be provided incentives when making trading decisions. This type of model shows that information frictions, such as what may arise when the trader is responsible for complex trading strategies or what may worsen during turbulent periods, will affect intermediary asset demand and equilibrium asset prices. In the agency-theoretic model, the stake of the insider (management, trader) can alleviate information frictions; thus, metrics that track this stake—for example, past returns of the firm - will affect asset prices. The agency-theoretic model also gives rise to a constraint on raising outside equity finance since such finance may dilute the stake of the insider. Thus, we can understand why equity capital and regulatory capital may affect asset demands. Andersen et al. (2019) develop a model where debt-overhang distorts the investment decision of the trader at a financial intermediary. The trader makes decisions to maximize value to shareholders, but given debt-overhang, such decisions differ from the frictionless benchmark. They show that traders under debt-overhang require a minimum return, roughly equal to the financial firm's credit spread, to purchase assets. Their approach allows one to understand the high returns on even near riskless trades in the last decade, and the comovement between such returns and financial firms' credit spreads. In this model, the debt-overhang friction reduces the private incentive to raise equity capital. Thus, the model also speaks to why regulatory capital requirements can affect asset demand and prices.

I view this theoretical research as a work in progress. Opening the box of the financial firm suggests that many other considerations may matter for the trading decisions of the firm. Capital allocation within firms, career concerns of traders, search for yield, and benchmarking effects all seem like considerations that may be of importance. Sorting out which of these are first-order, and in which asset markets and states-of-the-world, is the research agenda that needs to be completed.

There is by now ample evidence that Modigliani-Miller fails for financial firms, and this failure meaningfully affects asset prices (see He and Krishnamurthy 2018 for a review of the evidence). Yet there is heterogeneity within intermediaries. We need to understand better the impact of these failures on different intermediary types and in different asset markets. Commercial banks are players in loan markets, bond markets, and derivatives markets. They are financed largely by deposits, some of which is subject to government insurance and regulatory constraints. Broker/dealers are active in derivatives and market-making activities across a broad array of asset markets. They are financed in short-term funding markets including wholesale money markets and repo markets. Hedge funds engage in complex trading strategies across a range of asset markets. They are financed by insiders' wealth, outside equity capital, and repo. Placing structure on the "asset demand" functions across these different types of intermediaries, as in the approach taken by Koijen and Yogo (2019), can shed light on the underlying factors driving trading at these intermediaries. This too is an important research agenda, and will draw on tools from asset pricing, industrial organization, and corporate finance.

Finally, I will mention a parallel stream of research to IAP in macroeconomics. There is a large literature that studies how intermediation frictions affect credit extension, via loan supply/loan rates, and then through such channels affect aggregate investment and consumption. See Brunnermeier et al. (2011) for a survey. If intermediaries are an important driver of asset prices, then we should expect that they will also affect macro quantities. This observation has two further implications. On the theoretical side, the consumption of the direct investing household I alluded to earlier will also be affected by intermediary frictions. This point is often lost in models with exogenously specified agent endowments, as is typical in asset pricing models. On the empirical side, the data studied by macroeconomists offer further moments for intermediary asset pricing models to match. Thus, connecting IAP and macroeconomics is another important avenue in this research agenda.

7. International Finance

Twenty years ago, international finance and finance were far apart from each other.[25] Over the past 20 years, a remarkable convergence took place. Will these two fields share a common path in the future, or will they diverge in order to meet specific challenges? I will use this question to organize my thoughts on the future of international finance.

The fundamental equation for finance is probably the asset pricing equation

$$\frac{P_t}{D_t} = \mathbb{E}_t \left[X_{t,t+1} \frac{D_{t+1}}{D_t} \right],$$

where P_t is the price of an asset, D_t is its dividend, $X_{t,t+1}$ is the stochastic discount factor, and $\mathbb{E}_t$ is the expectation operator. It is not so much that everyone agrees that this equation holds, but that pretty much everybody agrees that it is a useful organizing principle. In some sense, even theories that rely on breaking this equation can be described in reference to it. For example, while neoclassical finance emphasizes rational expectations and time-varying risk premia, behavioral economics is centered on irrational expectations, financial frictions, and the resulting arbitrage opportunities.

The fundamental equation for international finance is a close cousin,

$$\frac{E_{t+1}}{E_t} = \frac{X^*_{t,t+1}}{X_{t,t+1}},$$

where E_t is the exchange rate between two currencies and $X_{t,t+1}$ and $X^*_{t,t+1}$ are the stochastic discount factors in these two currencies. This equation plays a similar role as an organizing principle in international finance as its counterpart does in finance.

Despite these fundamental similarities, there are differences of emphasis between the two fields. First, heterogeneity is more central to international finance than it is to finance. Heterogeneity simply cannot be avoided in international finance. In some sense, international finance starts with two countries and two investors. Second, frictions are more central to international finance than they are to finance. Indeed, and despite decades of international financial integration, there are many more frictions in financial markets across countries than within countries. Third, currencies are more central to international finance than they are to finance. It does seem to make a big difference that assets are traded in one currency or another. Fourth, the role of governments is more central to international finance than it is to finance. Governments interfere in many different ways in the trading of assets across countries, more so than within countries.

Turning to the future, it is clear that there are both common and specific long-standing problems that are likely to occupy the two fields in the coming

[25] This subsection is the perspective of Emmanuel Farhi.

decades. Common long-standing problems include the identification of the economic determinants of beliefs $\mathbb{E}_t$, the economic determinants of risk premia or equivalently of stochastic discount factors $X_{t,t+1}$ and $X^*_{t,t+1}$, the economic determinants of portfolios. They also include what I will call the "disconnect" problem: the fact that it seems difficult to connect the stochastic discount factor $X_{t,t+1}$ to an actual preference-based marginal rate of substitution $MRS_{t,t+1}$ of a well-identified marginal investor between periods t and $t+1$, or the real exchange rate $E_t P^*_{F,t}/P_{H,t}$ to the actual preference-based marginal rates of substitution $MRS_{F,H,t}$ between foreign goods F and home goods H.[26] Other common long-standing problems include the identification of the key market failures and externalities (fire sales from financing constraints, aggregate demand externalities from nominal rigidities, search externalities, etc.) as well as the role and transmission of policy (monetary, fiscal, prudential, etc.).[27]

International finance also faces specific challenges with no counterparts in finance. First, there is the Mussa puzzle, or the observation that the volatility of nominal and real exchange rates are closely related:[28]

$$vol(\frac{E_t P^*_t}{P_t}) \approx vol(E_t).$$

Second, there is covered-interest-parity (CIP) arbitrage violation, or the observation that the forward premium is divorced from the interest rate differential[29]

$$\frac{F_{t,t+1}}{E_t} \neq i_t - i^*_t.$$

Third, there is the large degree of home bias in portfolios across countries. Fourth, there are the destabilizing effects of volatile capital flows in emerging markets. Fifth, there are the economic determinants of government behavior in these countries. Sixth, there are the economic determinants and implications of exchange rate regimes (fixed exchange rates, floats, managed floats, etc.).[30] Seventh and finally, there are the importance of the international monetary system and the special role of the United States as the preeminent issuer of safe and liquid reserve assets, its associated role as the world banker and the exorbitant privilege that comes with it, and the resulting pattern of global imbalances.[31] How long will the dollar continue to dominate as a reserve and invoicing currency? How long will the United States keep playing a dominant

26 See, e.g., Itskhoki and Mukhin (2017) and Lilley et al. (2019),

27 See, e.g., Jeanne and Korinek (2010), Bianchi and Mendoza (2010), Bianchi (2011), and Farhi and Werning (2016).

28 See, e.g., Itskhoki and Mukhin (2017).

29 See, e.g., Du et al. (2018).

30 See, e.g., Ilzetzki et al. (2017).

31 See, e.g., Gourinchas and Rey (2007), Caballero et al. (2008), and Gourinchas et al. (2010).

role as a world lender of last resort through its network of swap lines? When will we transition to a more multipolar world? Will that transmission be smooth or turbulent? Will the supreme reign of the dollar come to an end in a Triffiin event similar to that which brought the end of the Bretton Woods system of fixed exchange rates?[32]

The two fields are actively tackling these challenges. In doing so, they sometimes take a common approach to deviate from the first and simplest models that rationalized the fundamental equations. For example, both fields now make ample room for market segmentation; recognize the role of financial intermediaries; incorporate financial constraints, illiquidity, and runs; try to capture irrationality and speculation; and allow for inattention.[33] International finance also sometimes breaks away from finance to address some of the central problems that are specific to the field. For example, it makes more room for nominal rigidities and political economy frictions such as limited commitment and the like. A question that arises, as the two fields deviate from the simple unifying paradigms of the fundamental equations, is whether they will splinter into a collection of local explanations to local questions, or whether new and richer global paradigms will emerge. Another is whether the two fields gravitate toward similar local and global theories. It seems that they would probably have a better shot at the truth if they did.

It seems clear that both fields will benefit from the arrival of large quality micro-datasets. It is a safe bet that it will force the fields to recognize the importance of heterogeneity and frictions even more so than they do today. In international finance, new data already allows us to grasp a new reality on disaggregated capital flows, portfolios, and balance sheets, and to recognize the importance of financial derivatives.[34] Similarly, we are beginning to gain an understanding of the heterogeneity and dynamics of beliefs.[35] And we are also making progress on the nature of nominal rigidities using data on disaggregated prices.[36] Similar trends are at work in finance. In the two fields, reduced-form empiricism will be a temptation, and the question is whether new and better structural theories will emerge to explain all this data.

8. An Asset Pricing View of Exchange Rates

I explore how recent advances in asset pricing have contributed to our understanding of exchange rates, and I outline promising areas for future

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32 See, e.g., Farhi and Maggiori (2018), Gopinath and Stein (2018), He et al. (2019), and Gourinchas et al. (2019).

33 See, e.g., Gabaix and Maggiori (2015) and Itskhoki and Mukhin (2017).

34 See, e.g., Maggiori et al. (2018) and Coppola et al. (2020).

35 See, e.g., Giglio et al. (2019).

36 See, e.g., Gopinath et al. (2020).

research, using the United States' role in the international financial system as a test case.[37]

8.1 Exchange rate valuation and decomposition

What are the determinants of a currency's value? By iterating on the bond investors' Euler equations, and by assuming conditional log-normality of exchange rates and interest rates, we can show that the log of the real exchange rate in units of domestic currency per unit of foreign currency is determined by future interest rate differences and future currency risk premia (Campbell and Clarida 1987; Froot and Ramadorai (2005); Clarida and Gali 1994):

$$s_t = E_t \sum_{\tau=0}^{\infty}(y^*_{t+\tau} - y_{t+\tau}) - E_t \sum_{\tau=0}^{\infty}(rp_{t+\tau}) + E_t \lim_{\tau\to\infty} s_{t+\tau},$$

where $y_{t+\tau}$ denotes the log of the real risk-free rate; $rp_t = E_t[rx_{t+1}] = y^*_t + y_t + E_t \Delta s_{t+1}$ denotes the log currency risk premium on a long position in the foreign currency. The asterisk (*) denote foreign variables. This equation has to hold regardless of the richness of the menu of traded assets.

The exchange rate level reflects a cash flow component, the interest rate differences, and a discount rate component, the currency risk premia. All else equal, an increase in the foreign country's interest rates will cause the foreign currency to strengthen, that is, to appreciate against the dollar, but an increase in the currency risk premium will cause the currency to depreciate.

Importantly, real interest rate differences across countries are quite persistent. Some countries have persistently low interest rates, and other countries have persistently high interest rates (Lustig et al. 2011; Hassan and Mano 2019). According to the igh interest rate currencies also need to have high currency risk premia, so that the persistent component of the interest rate differences is (partly) offset by the persistent component of the currency risk premia, if real exchange rates are to be stationary. In other words, Switzerland and Japan have to convince global bond market investors to accept negative currency risk premia to keep their currency from weakening, while Australia and New Zealand need large and positive currency risk premia to keep their currency from strengthening.

This implication of the exchange rate valuation model is borne out by the data. Investors earn an unconditional currency carry trade risk premium by going long in currencies that have high interest rates on average, even if they do not condition on current interest rates (Lustig et al. 2011; Hassan and Mano 2019). This is often referred to as the unconditional version of the currency carry trade. In equilibrium, investors have to believe that long positions in low interest rate currencies, such as the Swiss franc and the Japanese yen, offer

[37] This subsection is the perspective of Hanno Lustig.

insurance against aggregate risk that is priced in global securities markets, while high interest rate currencies expose their portfolios to more global risk.

High interest rate currencies depreciate in bad states of the world. Lustig et al. (2011) find that high interest rate currencies depreciate when volatility in global stock markets increases.[38]

8.2 The role of the United States in the international financial system

In the typical carry trade pattern of global capital flows, the United States looks like an outlier. The United States is an example of a country with low real interest rates that has been running persistent current account deficits. The United States has accumulated a large, negative net foreign asset position against the rest of the world as a result. The composition of the United States balance sheet against the rest of the world is unusual. The United States borrows by issuing Treasury bonds and other safe assets, and then the United States takes a long position in risky foreign assets. As a result, the United States manages to make money on its negative net foreign assets position. This has been referred to as the "exorbitant privilege" of the United States.

The insurance view. In the neoclassical complete markets benchmark, the exceptional role of the United States has a natural interpretation. The United States is the world's disaster insurance provider. The United States insures the rest of the world against adverse shocks, as is argued by Gourinchas and Rey (2007) and Gourinchas et al. (2010). In equilibrium, the least risk-averse investor, in this case the United States, insures other investors against adverse shocks. When disaster strikes, the insurance contract calls for large net transfers from the United States to the rest of the world. To generate these transfers, the dollar depreciates in real terms.[39]

The insurance view of the United States role in the international financial system faces two main challenges. I will use the great financial crisis (GFC) of 2007–2008 to highlight these challenges. First, it is not at all clear that there were large net transfers from the United States to the rest of the world during the GFC. There was a striking collapse of global trade during the GFC. Any cross-country transfers that did occur were probably smaller than what would be predicted by the model. Second, the dollar tends to appreciate in the case of large adverse shocks to the global economy. This is exactly what happened during the GFC.

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38 Menkhoff et al. (2012) find that baskets of high interest rate currencies depreciate when global FX volatility increases. Lettau et al. (2014) find that the downside betas of high interest rate currencies are higher.

39 Maggiori (2017) reinterprets this insurance arrangement by imputing a central role to financial intermediaries. In Maggiori''s model, United States' intermediaries are better equipped to hedge against adverse shocks than their foreign counterparts. In this risk-sharing arrangement, the United States can run large and persistent current account deficits in anticipation of surpluses during rare disasters. Similarly, Chien and Naknoi (2015) develop a model with heterogeneous agents in which the United States has a larger mass of sophisticated traders than the foreign countries. Their model has similar predictions.

The safe asset view. In the safe asset view, the United States is different because it is the sole supplier of the world's safe assets, and the dollar is the world's reserve currency (Farhi and Maggiori 2018; Caballero et al. 2008; Gopinath and Stein 2018; Caballero and Krishnamurthy 2008).

Investors earn a large, extra convenience yield when they buy dollar-denominated assets, especially Treasury bonds. As a result, the United States earns a potentially large amount of seignorage revenue on bonds sold to foreign investors. When foreign investors derive an extra convenience yield from holding United States Treasury bonds, this drives a wedge between the yield on the United States Treasury bonds and the yield on an equivalent foreign bond that is hedged back into dollars. Du and Schreger (2016) and Jiang et al. (2018) use the Treasury basis as an empirical measure of the extra convenience yield earned by foreign investors. Starting from the adjusted bond Euler equations, they derive an adjusted expression for the fundamental valuation equation of the dollar exchange rate:

$$s_t^{*/\$} = E_t \sum_{\tau=0}^{\infty} (\lambda_{t+\tau}^{\$,*} - \lambda_{t+\tau}^{*,*}) + E_t \sum_{\tau=0}^{\infty} (y_{t+\tau}^{\$} - y_{t+\tau}^{*}) - E_t \sum_{\tau=0}^{\infty} (rp_{t+\tau}^{*}) + E_t \lim_{\tau\to\infty} s_{t+\tau}.$$

Part of the discount rate component in the exchange rate valuation component has been relabeled as a convenience yield term. An increase in the convenience yield $\lambda_{t+\tau}^{\$,*}$ that foreign investors derive from their holding of dollar-denominated safe assets, relative to the same yield on foreign safe assets $\lambda_{t+\tau}^{*,*}$, causes the dollar to appreciate instantaneously. This prediction has empirical support. The variation in the U.S. Treasury basis has explanatory power for the dollar exchange rate; other bond bases do not have the same explanatory power for other bilateral exchange rates. Part of the discount rate component we measured earlier is now recast as a convenience yield component.

Jiang et al. (2018) find that these extra convenience yields foreign investors earn when holding Treasury bonds are larger than 2% per annum. More than 90% of this convenience yield is attributable to the dollar exposure, not the safety of Treasury bonds, consistent with recent evidence that international bond investors seem to be subject to dollar bias (Maggiori et al. 2018).

This safe asset model has radically different implications from the benchmark model. When the world economy experiences an adverse shock, the flight-to-safety will tend to cause the dollar to appreciate. During the onset of the great financial recession in 2008, the dollar appreciated by 30%, and the United States generated a larger dollar amount of seignorage revenue from the sale of Treasury bonds and other safe assets. In case of a global crisis, there is a net transfer from the rest of the world to the United States.

In this safe asset model, international capital flows can obviously be destabilizing. For example, safe asset demand creates an incentive to produce more dollar-denominated safe assets in the United States, potentially giving rise to excessive leverage in the United States in the run-up to the GFC. In other countries, especially emerging market countries, issuers have an incentive to issue bonds denominated in dollars. This in turn gives rise to currency mismatch. Much more empirical work in the coming years is needed to explore and test the implications of these two different paradigms, particularly their implications for exchange rates.

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