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Adaptive learning and distributional dynamics in an incomplete markets model

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ABSTRACT

Recent research shows that several DSGE models provide a closer fit to the data under adaptive learning. This paper extends this research by introducing adaptive learning in the model of Krusell and Smith (1998) with uninsurable idiosyncratic risks and aggregate uncertainty. A first contribution of this paper establishes that the equilibrium of this framework is stable under least-squares learning. The second contribution consists of showing that bounded rationality enhances the ability of this model to match the distribution of income in the US. Learning increases significantly the Gini coefficients because of the opposite effects on consumption of the capital-rich and of the capital-poor agent. The third contribution is an empirical exercise that shows that learning can account for increases in the income Gini coefficient of up to 25% in a period of 28 years. Overall, these findings suggest that adaptive learning has important distributional repercussions in this class of models.

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1. Introduction

Expectations play a crucial role in representative-agent macroeconomic models. This paper extends the study of the role of expectations to the incomplete-markets model with uninsured idiosyncratic risk and aggregate uncertainty of Krusell and Smith (1998). In a heterogeneous-agent economy, agents must form expectations about the aggregate capital stock because this quantity has an immediate effect on their budget constraints through the determination of returns to productive factors. The main objective of this paper is to examine the effects of learning about the aggregate capital level on the endogenous distribution of wealth. I find that boundedly-rational expectations on the stock of aggregate capital significantly increase wealth and income inequality due to the opposite effects on optimal consumption levels of capital-rich and capital-poor agents. Through a calibration exercise I find that a change of two standard deviations to the expected capital stock increases the income Gini coefficient by an average of 25% in a time span corresponding to 28 years. Furthermore, these increases in inequality are very persistent, taking much longer to subside than to emerge.

The notion of macroeconomic fluctuations driven by expectations dates back to Pigou (1926) who suggests that expected gains in total factor productivity cause aggregate investment to rise, and therefore boost economic activity. Pigou's compelling insight hinges on the assumption that all agents in the economy respond to an expectational shock in an identical fashion – in other words, the argument uses a representative-agent logic. Yet, in the presence of a non-degenerate distribution of wealth in the economy, it is not straightforward to apply Pigou's logic to understand the consequences of an

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expectational shock regarding aggregate investment on economic outcomes. To see this point, consider the consumption-saving decision of an agent whose income depends on wages and interest payments. With competitive factor markets, diminishing marginal returns, and complementary factors of production, an increase in expected aggregate investment produces two distinct effects on the budget constraint of a non-representative agent. First, the complementarity of production factors implies that the increase in the stock of capital causes the expectation of wages to increase, thus expanding the agent's intertemporal budget set. This is a positive impact from the point of view of the agent. Second, higher expected investment implies a decrease in the expected rental rate of capital. Thus, there is also a *negative* impact on the agent's budget set.[1] Which one of these two effects dominates depends (among other factors) on the amount of capital owned by a particular agent: the economic significance of the second negative effect is higher for capital-rich than for capital-poor agents. This implies that although agents are otherwise identical, in response to an expected increase in aggregate investment, the capital-rich ones save more, while the capital-poor ones save less. Consequently the distribution of wealth becomes more unequal, while its first moment may either increase or decrease, depending on the initial distribution of capital. This paper develops and demonstrates this intuition using the standard heterogeneous-agent economy of Krusell and Smith (1998).

This paper contributes to three strands of the learning literature. First, Packaléen (2000) and Evans and Honkapohja (2001) consider the learnability of RBC-type models, while Evans and Honkapohja (2003) and Bullard and Mitra (2002) study the learnability of new-Keynesian models. These studies assume complete markets, and the learnability of equilibria of incomplete-markets DSGE models has not been established before. Second, the present work is also related to the line of research on the effects of learning on macroeconomic aggregates in general equilibrium models. Bullard and Duffy (2001) and Williams (2004) find that least-squares learning does not produce strong effects on the aggregate dynamics of various log-linearized representative-agent models. In contrast, Eusepi and Preston (2011) study the model of Beaudry and Portier (2007) under adaptive learning and find that bounded rationality yields a closer match to US data on output, consumption, and investment. Similarly, Evans and McGough (2005) find that in an economy in which the monetary authority follows a Taylor rule, learning increases the volatility of the macroeconomic aggregates. Branch and Evans (2011) show that asset price bubbles may arise under least squares learning when agents estimate the risk-return tradeoff from data on past prices. Milani (2007) finds that a standard monetary DSGE model with learning is consistent with the persistence of inflation dynamics, without the inclusion of any other features such as habit persistence or inflation indexation. For an extensive survey of this literature see Evans and Honkapohja (2009) and Evans and Honkapohja (2013). Consistently with this literature, I find that adaptive learning yields a closer match to the data along the unexplored dimension of the wealth and income distributions.

Third, this paper is related to the literature on heterogeneous expectations. Kurz (1994) provides a theoretical motivation to models with heterogeneous expectations, and Evans and Honkapohja (1996) give sufficient conditions for global convergence of heterogeneous-expectations economies to a rational-expectations equilibrium. Brock and Hommes (1997), Brock and Hommes (1998), and Branch and McGough (2008) show that expectations heterogeneity can account for very complex (chaotic) dynamics in various asset pricing models. Branch and Evans (2006) study situations in which expectations resulting from misspecified models may coexist in equilibrium. Branch and McGough (2011) show that business cycle fluctuations are amplified in the presence of heterogeneous expectations. A recent survey of the literature on non-rational expectations is in Woodford (2013). The approach followed in this paper is original in the sense that while expectations are shared by all the agents in the economy (and therefore expectations are not heterogeneous) the common expectational operator interacts significantly with the endogenously determined wealth distribution and therefore the *consequences* of bounded rationality are different on different agents. This modeling of expectations can be motivated empirically by the substantial revisions that aggregate investment data are routinely subjected to, which imply both an objective uncertainty surrounding the real-time information on aggregate capital, as well as an economy-wide common learning process concerning these data.

In this paper, the key driver of the changes in the distribution of wealth is the inverse expected co-movement of wages and capital rental rates. This negative correlation has been introduced by the previous literature in at least three different ways. Kumhof and Rancière (2010) consider a shock to the bargaining power of separate categories of agents. Ríos-Rull and Santaeulalia-Llopis (2010) introduce a stochastic parameter controlling the labor share of output in the production function. Graham and Wright (2010) and Shea (2012) assume that agents learn about factor payments by using information provided by the markets. I adopt a fourth possibility, consisting of changing the agents' expectation of the aggregate capital stock. This strategy is parsimonious since adaptive learning affects the linear regression model that the agents of this model economy are already assumed to use to form expectations. For this reason I implement the algorithm originally proposed by Krusell and Smith (1998), even though more recent alternatives have been proposed in the literature, see for example Algan et al. (2008), Reiter (2009), Kim et al. (2010), Den Haan and Rendahl (2010), Young (2010), and Maliar et al. (2010).

The previous heterogeneous-agents literature offers at least two alternative approaches to obtain a more unequal distribution of wealth in this model. First, Krusell and Smith (1998) themselves address this issue by introducing additional heterogeneity in the agents' discount factors. Second, Chang and Kim (2006) obtain high wealth inequality – without discount factor heterogeneity – by calibrating the agents' income process on the basis of the Panel Study of Income

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[1] This argument presumes that the agent has a positive net worth.

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