Pseudo-wealth and Consumption Fluctuations

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This paper provides an explanation for situations in which the fundamental state variables describing the economy do not change, but aggregate consumption experiences significant changes. We present a theory of pseudo-wealth—individuals' perceived wealth that is derived from expectations of gains in bets arising from heterogeneous expectations. This wealth is divorced from society's real assets. The creation of a market for bets necessarily generates positive pseudo-wealth. Changes in the magnitude of differences of prior beliefs will lead to changes in expected wealth and hence to changes in consumption, implying instability in aggregate and individual consumption and ex-post intertemporal consumption misallocations. Moreover, "completing markets" through the creation of a new market for bets can increase individual and aggregate risk. With a utilitarian social welfare function, completing markets leads to lower welfare ex-post, but the first theorem of welfare economics (evaluating each individual's well-being on the basis of her ex ante beliefs) still holds, raising unsettling questions for welfare analysis. We also show that if the planner uses beliefs that are consistent, then the betting equilibrium would be Pareto inferior.

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I. Introduction

This paper provides a new explanation for an important macro-economic phenomenon: There are many occasions in which the (physical) state variables describing the economy (the level of human and natural capital, the amount of plant and equipment) do not exhibit large changes but the state of the economy, including the levels of consumption of the society, changes dramatically.

This paper puts forward the hypothesis that at least some of this volatility arises from fluctuations in what we call pseudo-wealth—wealth that individuals perceive they have, but which is to some extent divorced from the physical assets that exist in society. We show that there can be sudden changes in the aggregate value of this pseudo-wealth, and that these fluctuations in turn can affect volatility in aggregate consumption and lead to ex-post intertemporal consumption misallocations (in the sense of having paths of individual and aggregate consumption that are not as smooth as the individuals and the society wished, and believed they were getting, ex-ante). We show, moreover, that the persistence of pseudo-wealth can lead to increasing levels of debt.

There is a challenge, however, in creating a persuasive theory of pseudo-wealth. If one assumes expectations are simply arbitrarily given, then a sudden change in expectations (the probability distribution of future states of nature) can obviously give rise to marked changes in the value of wealth. There is some evidence that large changes in perceptions occur during times of crisis.[1] The problem with this theory is that the task of explaining consumption volatility is too easy. This is a

[1] See Hoffman, Post, and Pennings, 2013; Carlin, Longstaff, and Matoba, 2014; Kozlowski, Veldkamp, and Venkateswaran, 2015.

legitimate critique of "animal spirits." More refined theories try to explain how distributions of beliefs change over time as a function of the new information the economy receives.

In this paper, we explore an explanation that is more tethered and less arbitrary. It is based on two key hypotheses:

1. There can exist large differences in prior beliefs that are sustained at least for a while. Differences in views can exist even when individuals have rational expectations, so long as they have access to different information that leads to different priors.[2] All that we require is that there is not common knowledge, implying that at least one of the assumptions which give rise to "common knowledge"—a state of affairs in which all individuals agree about the probabilities of different events— is not satisfied.

2. Differences in views, with betting markets, give rise to the creation of pseudo-wealth, with the aggregate expected wealth of market participants exceeding true wealth –i.e., a level of wealth consistent with societal beliefs that are feasible. Each side "expects" to win. Betting markets also lead to more uncertainty. If the positive effect of pseudo-wealth creation on demand today is larger than the negative effect of uncertainty (due to the increase in precautionary savings), the result will be an increase in current levels of consumption. It is inevitable that (later) someone's expectations will be disappointed—indeed, in any betting market, someone is disappointed. The point here is that the elimination of (or reduction in) a betting opportunity (including the resolution of a class of bets, as a result of

[2] Differences in priors are a necessary condition for speculative trade, i.e. trade that is unrelated to differences in preferences, endowments, or constraints. In models with heterogeneous information but common priors, no-trade theorems apply (Milgrom and Stokey, 1982), unless rationality is not common knowledge (Neeman, 1996). Differences in priors could also arise as the consequences of behavioral biases. For our analysis what matters is that the priors are different, independently of what creates those differences.

the occurrence of the event about which the bets were taken) will lead to destruction of pseudo-wealth. Thus, if pseudo-wealth is quantitatively significant, then this moment will have macroeconomic significance.[3]

We present a model of two agents who disagree in the probability that a sunspot event occurs.[4] There is a market for short-term bets, and given the disagreement of beliefs, in equilibrium both agents will engage in a bet. They both believe they have a relatively larger chance of winning, hence they both feel wealthier. However, this cannot be true for the aggregate, as the bet is not creating any real wealth. Once the sunspot occurs, the bet disappears, and even though no real wealth is destroyed, the sum of the expected wealth of the two agents together decreases.[5]

A financial innovation such as the creation of a market for bets in a context of heterogeneous beliefs will lead to increases in expected wealth that will tend to increase consumption but also increases wealth volatility, and that will tend to increase savings for precautionary motives. We restrict the analysis to the cases where the wealth effects dominate over the precautionary savings effects.[6] Our main result is that the interaction of disagreement of beliefs with a market for bets will create excessive ex-post aggregate consumption volatility, excessive either with respect to a world of common beliefs or to a world with no market for bets. At the moment in which the bet disappears, the agent betting in favor of the sunspot

[3] There is, of course, the possibility of the simultaneous creation and destruction of pseudo-wealth, with offsetting macroeconomic effects; but for reasons suggested in the next footnote, it is even more likely that they not fully offset than in the case of technology shocks which affect individual workers and firms. Indeed, the existence of technology shocks with macroeconomic significance will typically give rise to divergences of views (e.g. about persistence and magnitude), in which case pseudo-wealth may amplify the effects of the shock.

[4] We focus on those events because we want to isolate the effects of pseudo-wealth changes from those of other changes. In practice, many bets are about matters of economic substance --such as whether there is a housing or oil price bubble. Such bets are especially likely to be associated with macroeconomic fluctuations; the magnitude of pseudo-wealth may increase, for instance, as a bubble continues, with wide divergences of views about whether there is a bubble and if so, when it will break. Of course, once it breaks, the pseudo-wealth created by the bets is reduced.

[5] The sunspot can be taken as a metaphor for an event that rarely occurs, like a structural transformation, over which there is not a long history to have properly learned the true probability distribution that governs it.

[6] Though even then, pseudo-wealth has macroeconomic consequences, depressing consumption in the short-run, but causing a positive macroeconomic shock upon the resolution of the bets.

will experience an increase in wealth, and the other agent will experience a decrease in wealth. However, the "pseudo-wealth" component of expected wealth will vanish, as the difference in views that was leading to a perception of higher wealth at the individual level will no longer be relevant. At this moment, aggregate consumption will decrease.

Accordingly, the financial innovation that completes the market will create risk in an economy that would be otherwise stable—but from the viewpoint of individual beliefs, this will be Pareto efficient. But if the planner had prohibited the bet, the society would have experienced a smoother path of consumption, and each individual's consumption profile would have been smooth. If we allow the planner to take a stance on beliefs, and the planner uses beliefs that are *consistent*, such that the sum of the planner's perceived probability of all possible states is equal to one, as in the case of "reasonable beliefs" analyzed in Brunnermeier, Simsek, and Xiong (2014), then the betting equilibrium would exhibit a lower level of social welfare, and indeed, using the planner's beliefs, each individual would be worse off.

Empirical motivation. The existence of pseudo-wealth is an important but neglected feature of any economy in which there is not common knowledge, i.e. in which individuals differ in their beliefs. Any macroeconomic analysis needs to account for why pseudo-wealth does or does not play an important role. There is ample evidence of lack of common knowledge and differences in beliefs as well as of changes in beliefs and in the magnitude of differences in beliefs. It is economic behavior to which these differences give rise that motivates this paper. The presumption is that if there are differences in beliefs, the market will create opportunities for economic transactions which give rise to the existence of pseudo-wealth that can be empirically significant. A challenge for macroeconomic modeling based on micro-foundations, largely ignored so far, is to explain why the seemingly large discrepancies in beliefs *do not* give rise to significant pseudo-

wealth, e.g. why preferences and beliefs or market constraints are such as not to give rise to significant pseudo-wealth—significant enough to have macroeconomic consequences.[7]

Here, we are suggesting something further: Pseudo-wealth may amplify the effects of technology shocks or "animal spirits" when these shocks create more dispersion of beliefs. Moreover, in some circumstances pseudo-wealth would be the *source* of the fluctuation, rather than just an amplifier. That would be so, for instance, if the innovation was purely of a financial nature, such that it did not affect the actual wealth of the economy, its capacity to produce goods and services, but only provided opportunities for "betting".

An important question is how significant pseudo-wealth in practice is, either as an amplifier or a source of cyclical fluctuations. Answering this question requires a careful empirical investigation—a step that we do not take in this paper. That empirical analysis would require, in the first place, data on beliefs. There is in fact direct empirical evidence that supports the premise of heterogeneous beliefs that underlies the concept of pseudo-wealth.[8] Much of this evidence comes from survey data—the explanatory power of survey data is receiving increasing recognition[9], and as such, survey data would be a natural place where to look for the appropriate data to verify the existence of large differences in beliefs as well as to test some of

[7] Indeed, institutional innovations over the past quarter century, e.g. structured finance and the lowering of transactions costs in equity and other asset markets, were touted as facilitating (ex ante) welfare enhancing transactions, which simultaneously might have been expected to give rise to more volatility in pseudo-wealth.

[8] This evidence, reviewed in the next section and in the next footnote, is in addition to the indirect evidence based on trading in assets; as argued in a number of papers on the importance of beliefs reviewed in the next section, the extent of this trading is hard to explain based solely on changes in individual circumstances.

[9] This view has been forcefully defended, for instance, by Gennaioli and Shleifer (2018). Giglio et al. (2019) not only document persistence of heterogeneity of beliefs, but also provide evidence on the link between beliefs revealed by surveys and real actions taken by survey respondents (the analysis focuses on a sample of U.S.-based clients of Vanguard, one of the world's largest asset management firms). Diether et al. (2002) analyze how analysts' differences of opinion on the earnings forecasts about stocks affect asset prices. On the other hand, trading volume has also been used as a proxy for the intensity of disagreement or dispersion of beliefs (for instance, Hong and Stein (1999) predict that negative skewness in returns will be most pronounced in periods of more trading volume, and Chen, Hong, and Stein (2001)'s empirical work confirm that prediction for the skewness in the daily returns of individual stocks).

the implications of the pseudo-wealth theory, e.g. to test whether causally these differences in beliefs could be a significant source of aggregate fluctuations.[10]

There are other dimensions of the analysis that must be noted. First, at the core of our analysis is the assumption that heterogeneity of beliefs can be a persistent feature of the environment.. Consistent with what is documented in empirical work on beliefs and with observed economic behavior, there are plausible conditions under which the economic system exhibits persistent heterogeneity in beliefs.[11]

Second, it is perfectly possible that periods of increasing dispersion of beliefs coincide with more uncertainty or lower confidence in beliefs—and the net effect could be a decrease in "betting". In fact, there is evidence that shows that disagreement increases when major events that make the environment more uncertain occur, such as the failure of Long Term Capital Management, the terrorist attacks of 9/11/2001, and the fall of Lehman Brothers (Carlin, Longstaff, and Matoba, 2014). A careful empirical investigation could shed light on the relative strength of these counteracting forces.

Ultimately, this paper offers a theoretical contribution with testable implications that can be distinguished from the implications of other related and complementary models for explaining cyclical fluctuations. Macroeconomic modeling based on micro-foundations has to come to terms with the fact that beliefs differ, that

[10] There are other pieces of evidence that also motivate our research: we know that variations in consumption can largely be explained by variations in (perceived) wealth (see Fair, 2019), although further research is needed to clarify that changes in pseudo-wealth do not have a different effect than changes in market wealth.

[11] Cao (2018), for instance, lays out an environment of incomplete markets in which the market selection hypothesis, that contends that the financial wealth of agents with incorrect beliefs trends towards zero in the long-run, holds, fails—one in which margin requirements protect the wealth of the optimists, hence the over-optimistic agents may survive, and even prosper by speculation. In reality, of course, some individuals may have better judgments in one area, others in another. They may both have overconfidence in their judgments in areas which are not of their competence. They thus may make profits from bets (investments) in one area, losses in others; but all the while, there may be betting opportunities, with variability in aggregate pseudo-wealth affecting macroeconomic fluctuations.

In our paper, the assumption that the event over which there is speculative trade is rare implies that there are not enough opportunities for the agents with the objective beliefs to prevail. By definition we do not get many observations of such events—even if it is the case that the system can process well events that are not rare. Much of what matters for macroeconomic dynamics has to do with events that are rare, in the particular sense that we are using the term.

differences in beliefs give rise to trade in assets and liabilities, that the possibility of those trades affects individuals' wealth perceptions and even the perceived value of aggregate wealth, and that changes in the magnitude of beliefs and trades have macroeconomic consequences.

Outline. The rest of the paper is organized as follows. Section I.A frames our paper within the existing literature. In section II, we present a simple framework that displays the presence of positive pseudo-wealth and analyze the implications for spending and savings of a financial innovation such as the creation of a market for bets in an environment featured by heterogeneous beliefs. Section III solves the model for tractable setting of the certainty equivalence case. Section IV summarizes the main results of the model in terms of consumption volatility. Section V discusses the limitations of our assumptions and possible extensions. We show that in richer economic structures, fluctuations in pseudo-wealth can also have effects on actual wealth as well as distributional consequences. Section VI presents the conclusions.

A. Related Literature

The issue of "excessive" consumption volatility has received much attention in the macroeconomics literature. The term "excessive" indicates that the actual consumption volatility cannot be explained by a benchmark model that would imply a more stable path of consumption relative to output. The benchmark model typically features a representative agent model with rational expectations and transitory shocks to output. The existing literature offers different types of deviations from that benchmark to explain the higher (relative to what one would have expected from the benchmark model) levels of consumption volatility

observed in times of high output volatility. In the discussion below of the various strands of research, we note differences in the empirical implications; some of these explanations should be viewed as complementary to that offered by the theory of pseudo-wealth: there are almost surely multiple drivers of the observed excesses in consumption volatility.

Aguiar and Gopinath (2007) introduce trend shocks in a real business cycle framework. The volatility of trend shocks is larger in emerging economies than in advanced economies, which implies the higher consumption volatility observed in the former set of economies.[12] But this approach does not really solve the quandary noted above: Unlike our approach, this approach requires large changes in the state variables (represented as permanent productivity shocks)—in some instances, larger than seems plausible—to explain large changes in consumption.

A related literature provides an explanation for changes in current behavior as a response to today's changes in *expectations* concerning the evolution of state variables in the future. For example, Beaudry and Portier (2004, 2006) and Jaimovich and Rebelo (2008) present a class of models where news about future total factor productivity drive changes in individuals' decisions that could lead to a downturn in the present. Relatedly, Lorenzoni (2009) presents a theory of "news shocks", in which business cycles are driven by changes in the expectations of the individuals about the present state of the economy—with expectations formed on the basis of noisy public sources of information regarding long-run shifts in aggregate productivity. Although in this family of models it is possible to have situations in which the state of the economy changes with no changes in the *current* state variables, these frameworks—unlike our framework—still rely on changes in

[12] See also Garcia Cicco, Pancrazzi, and Uribe (2010) for a critical view of this approach.

the *future* state variables that are anticipated *in the present* for explaining changes in the state of the economy observed *in the present*.

Angeletos and La'O (2013) provide an explanation that can account for shifts in the expectations of economic activity with no changes in the fundamentals that describe the economy. Their theory accommodates the notion of animal spirits in a model of rational expectations with a unique equilibrium in an environment featured by incomplete information and imperfect communication. What drives fluctuations in the economy is an extrinsic shock[13] that they dub "sentiment shock", that can effectively alter beliefs in equilibrium. These shocks can be interpreted either as shocks to beliefs of endogenous economic outcomes — an interpretation corresponding to shocks to first-order beliefs — or as shocks to the beliefs that each agent (or island) forms about the beliefs of other agents (or islands) about her productivity — an interpretation corresponding to shocks to second-order beliefs.[14] Imperfect communication can result in a positive correlation in the degree of agents or islands' optimism or pessimism about the terms of trade with the other islands that each of them will face may emerge endogenously as agents learn from realized market outcomes, and this can give rise to macroeconomic fluctuations. The pseudo-wealth theory that we develop in this paper does not require any shock to the expectations of endogenous market outcomes. The increase in individual and aggregate consumption that occurs when the market for bets is created is the pure consequence of the speculative trade, that is unrelated with any market outcomes other than the expectation of a gain associated with the bet. In turn, the fall in aggregate consumption that occurs when pseudo-wealth is destroyed is also unrelated to expectations of market outcomes, but it is the consequence of the

[13] An extrinsic shock is a shock to residuals that does not affect any payoff.

[14] Angeletos and La'O (2013)'s preferred interpretation is as shocks to first-order beliefs, a concept that is more amenable for empirical analysis, as surveys generally only contain information on first-order beliefs.

realization of a rare event that eliminates any difference in prior beliefs. In our framework, agents fully agree on any possible market outcome rather than the betting outcome probabilities at all moments. Besides, in the theory of pseudo-wealth the evolution of second-order beliefs is uninteresting: the premise is that before the realization of the rare event, agents "agree to disagree".[15]

The literature on learning as the basis of formation of expectations introduces deviations from the *full information rational expectations* hypothesis (cf. Evans and Honkapohja, 2001). Models with learning can account for a high level of volatility of expected wealth (and thus of consumption) due to the possibility of revisions of expectations. Accordingly, these models lead to larger macroeconomic volatility and endogenous business cycles (for example, Boz, Bora Durdu, and Daude (2011); Heymann and Sanguinetti (1998), Pintus and Suda, 2015). Both this paper and the learning literature are predicated on imperfect knowledge. In both, changes in beliefs have real macroeconomic effects and can lead to volatility. While in the learning literature, macroeconomic fluctuations are related to changes in *average* beliefs that have macroeconomic consequences, here, fluctuations can arise even if there are no changes in average beliefs: it is changes in the *dispersion* of beliefs which drives changes in aggregate consumption, and these changes can be triggered in a variety of ways.

There is a large literature that analyzes the consequences of heterogeneous beliefs. Kurz and Motolese (2001) present a theory of *rational beliefs* (defined in Kurz, 1994) in which the distribution of beliefs in the market is the most important mechanism of propagation of economic volatility. While the macroeconomic equilibrium is generically sensitive to the distribution of beliefs, several important papers have explored in particular the consequences of financial market constraints,

[15] For an analysis of the conditions under which agents can or cannot agree to disagree, see Geanakoplos (1989).

such as limits to short sales. Geanakoplos (2010) offers an approach for explaining excessive volatility of asset prices based on the interaction between heterogeneous expectations, collateral constraints, and leverage. Bad news in the economic environment can be amplified through the interaction between leverage and collateral constraints, leading to large changes in the "marginal buyer"[16] of an asset, and thus in asset market prices. In this approach, not everyone's expected wealth is reduced after an adverse shock. Only the expected wealth of the optimists who owned assets decreases. In our approach, both optimists and pessimists may suffer a decrease in expected pseudo-wealth after certain shocks, as opportunities for betting are reduced: the betting market had previously allowed them to exploit differences in beliefs in a way that led all of them to feel too "optimistic" about their future wealth.[17] Scheinkman and Xiong (2003) show how speculative behavior—defined as the agent's willingness to pay a price for an asset above her valuation of it, due to the belief that he will be possible to sell it at an even higher price in the future—in a context of short-sale constraints and overconfidence (each agent overestimates the informativeness of the signals they receive, thus agents' forecasts differ, they know that, and they agree to disagree) creates asset price bubbles. In our framework, agents do not speculate on the overvaluation made by other agents—they simply make betting and consumption decisions that they believe are optimal, independent of the potential behavior of others; and the results are not generated by financial constraints. Importantly, in their model, financial innovations which remove, or allow market participants to circumvent, such constraints would presumably reduce volatility; in our model, financial innovations which allow more betting opportunities may increase volatility.

[16] The marginal buyer, who is the least optimist of the agents who buy the asset, is a more pessimistic agent after a bad shock.

[17] In other cases, the shock induces a transfer of wealth from an individual to another (the resolution of the bet), but there is a reduction in aggregate pseudo-wealth and aggregate consumption.

More generally, the paper is related to a sizable literature that investigates the consequences of financial innovations and financial constraints in an environment of heterogeneous beliefs, such as Fostel and Geanakoplos (2012), Simsek (2013a, 2013b), among others. The closest contribution to this paper is Iachan, Nenov, and Simsek (2015) (INS henceforth). While INS focus on the effects of a financial innovation (that could be equivalent to the creation of a market for bets in this paper) on savings, we focus both on the moment of the innovation (in which a new betting opportunity is created) and especially on the moment in which the betting opportunity disappears, and analyze the behavior of consumption, betting, and savings at those moments. Also, while INS focus on cases in which substitution effects dominate over income effects, we focus on the opposite case.[18] Both papers could be seen as complementary.

This paper is the first step of a research agenda outlined in Guzman and Stiglitz (2015) that intends to offer a general framework for understanding situations in which large changes in macroeconomic behavior are observed with no counterpart in the size of changes of the state variables describing the economy.

II. A baseline model of pseudo-wealth

A. Environment

The environment features a small open economy with two infinitely lived representative agents, indexed by $i = A, B$.

In every period, each agent receives the same constant exogenous endowment of a single consumption good, denoted by $y > 0$.

[18] Diamond and Stiglitz (1974) have demonstrated under what general conditions the optimal value of the control variable increases or decreases when there is a mean utility preserving increase in risk.

There is a Poisson probability λ for the arrival of a one-time exogenous event, a sunspot. There is disagreement on the value of λ: agent *A* believes that the sunspot is more likely to occur than agent *B* does, i.e., $\lambda^A > \lambda^B$.

Agents can borrow in the international credit market at the risk-free interest rate *r*.[19]

We assume the instantaneous utility function $u(c_t^i)$ is continuous and strictly concave, $u'(c_t^i) > 0$ and $u''(c_t^i) < 0$, where $c_t^i \geq 0$ is the level of consumption of individual *i* in period *t*.

B. States

The set of state spaces in period t, Z_t, is dependent on the history of previous states. Until a sunspot occurs, there are two possible states: $Z_t = \{S, O\}$ if $z_j = O \ \forall z_j \in z^{t-1}$, where z_t is the state realization in period t, S refers to the sunspot state and O to the no-sunspot state, and z^t is the history of states until period t, $z^t = \{z_0, \dots, z_t\}$. Once the sunspot occurs, it cannot occur again, and the state will be $z_t = O$ forever, i.e. $Z_t = \{O\}$ if $\exists z_j = S$, for any $z_j \in z^{t-1}$. The sunspot can then be interpreted as a shock to prior beliefs—a shock that vanishes any difference in agents' priors.

Figure 1 depicts the tree of possible states before the occurrence of the sunspot.

[19] We adopt the assumption of an open economy in order to analyze more clearly the consequences of pseudo-wealth creation and destruction on borrowing and aggregate demand. In the case of an endowment economy that is closed, creation of pseudo-wealth would only lead to an increase in the real interest rate—and aggregate consumption would be equal to the aggregate endowment in every period. Although we do not analyze the case in which output is endogenous and requires capital as an input, we conjecture that in that case, in a closed economy, the creation and destruction of pseudo-wealth would affect the process of capital formation: If the creation of pseudo-wealth increased the demand for goods, the real interest rate would increase and investment would decrease. The general point, valid both in the open and in the closed economy, is that the fluctuations in pseudo-wealth will have real effects that may act as amplifiers of cyclical fluctuations.

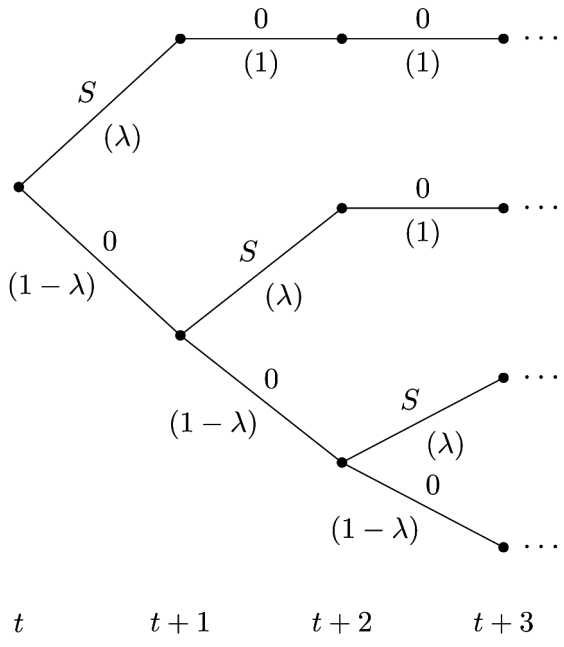

FIGURE 1. STATE OF SPACES

C. Bets and pseudo-wealth

We assume there is a market for short-term bets. Given the disagreement on λ, agents will bet in equilibrium.

The existence of the market for bets completes the market, in the sense that for all agents and for all states there is an available asset such that the payoff in one state is positive and in the other state is zero.

Bets have two effects on the agents' decisions:

1. Given the disagreement on the true value of λ, bets will create pseudo-wealth. Because of the bet, each party believes that he is wealthier. Thus, the perceived aggregate wealth exceeds the total "true" wealth. The larger

the size of the bet and the larger the discrepancy of beliefs on the probability of occurrence of the sunspot, the larger will be the pseudo-wealth. This effect will tend to increase consumption.

2. Bets will create uncertainty about expected wealth. In a general setup, this effect will tend to increase precautionary savings.

Therefore, every additional dollar of bet will be associated with a marginal benefit that comes from the perceived increase in wealth, and a marginal cost that comes from the increase in the variance of future expected wealth.

In every period the bet gets resolved. One side or the other wins the bet, and the pseudo-wealth that was created gets destroyed. If that were the whole process, pseudo-wealth would be ephemeral, with no real macroeconomic consequences.

If, however, differences in beliefs persist, individuals may once again engage in a bet, and so new pseudo-wealth is created. This destruction of pseudo-wealth but creation of new pseudo-wealth will occur until $z_t = S$.

In the betting equilibrium, agent A will pay p_t to agent B in period t. If $z_t = S$, agent B pays 1 to agent A, while if $z_t = O$, agent B pays nothing. Formally, the bet net returns ψ_t^i are described as follows:

$$\psi_t^A = \begin{cases} 1 - p_t, & z_t = S \\ -p_t, & z_t = O \end{cases}$$

$$\psi_t^B = \begin{cases} -(1 - p_t), & z_t = S \\ p_t, & z_t = O \end{cases}$$

D. Optimization

Consumers are forward-looking. In period *t*, each agent chooses a sequence of consumption, borrowing, and bets in order to maximize the expected present discounted value of utility,

$$max_{\left\{c_j^i(z_j),d_j^i(z^j),b_j^i(z^j)\right\}_{j=t}^{\infty}} E_t^i \sum_{j=t}^{\infty} \beta^{j-t}\, u\left(c_j^i(z^j)\right), \qquad i = A, B$$

subject to the budget constraints

$$c_t^i(z_t) + (1+r)d_{t-1}^i(z^{t-1}) = y + d_t^i(z^t) + \psi_t^i(z_t)b_t^i(z^t)\ \forall t\ i = A, B$$

where $d_t^i \in \mathbb{R}$ and b_t^i denote denote net borrowing and the net betting in favor of the sunspot state by agent i in period t, respectively; and also subject to the transversality condition

$$\lim_{j\to\infty} \frac{d_j^i}{(1+r)^j} = 0, \qquad i = A, B$$

Every time the no-sunspot state occurs, there will be a winner and a loser of the bet but the tree of future states will be the same as one period before. That is, the realizations of states act as wealth shocks, which implies a need to re-optimize in each period. Thus, the evolution of (individual and aggregate) borrowing and betting will be history dependent, making consumption spending also history dependent.

We will also assume (for simplicity) that $\beta(1+r) = 1$.

E. Consumption responses to increases in risk and expected wealth

The response of the individual's consumption and savings to the creation of the market for bets will depend on the agents' preferences. Suppose for the sake of

simplicity and only for the analysis of this section that there are only two periods, $t = 0,1$, and in $t = 0$ the creation of a market for bets that will be opened in the morning of $t = 1$ is announced. Suppose individuals' beliefs are symmetric: $\lambda^A - \frac{1}{2} = \frac{1}{2} - \lambda^B$. In this case a higher value of λ^A represents a larger dispersion of beliefs. Agent A will maximize

$$u(c_0^A) + \beta\left[\lambda^A u\left(c_1^A(S)\right) + (1-\lambda^A)u\left(c_1^A(O)\right)\right]$$

subject to the budget constraints

$$c_0^A = y + d_0^A$$

$$c_1^A(S) = y + (1-p)b^A - (1+r)d_0^A$$

$$c_1^A(O) = y - pb^A - (1+r)d_0^A$$

Before the creation of the market for bets, $c_t^A(z_t) = y \ \forall t, \forall z_t$. But betting will create a wealth effect and an increase in the variance of consumption in $t = 1$, that will turn affect consumption and savings decisions in $t = 0$. Lemma 1 shows that when utility is strictly increasing in consumption, the creation of the market for bets will lead to positive betting in equilibrium, thus creating a positive wealth effect.

Lemma 1: Suppose u is differentiable and $u' > 0, u'' < 0$, $\lambda^A > \lambda^B$. Then, $b^A = -b^B > 0 \ \forall i$ when the market for bets is created.

Proof: From the first order conditions of the utility maximization problem,

$\lambda^A(1-p)u'\left(c_1^A(s)\right) - (1-\lambda^A)pu'\left(c_1^A(O)\right) \leq 0$, $b_0^A \geq 0$, and

$\left[\lambda^A(1-p)u'\left(c_1^A(s)\right) - (1-\lambda^A)pu'\left(c_1^A(O)\right)\right]b_0^A = 0$

$\lambda^B(1-p)u'\left(c_1^B(s)\right) - (1-\lambda^B)pu'\left(c_1^B(O)\right) \geq 0$, $b_0^B \leq 0$, and

$\left[\lambda^B(1-p)u'\left(c_1^B(s)\right) - (1-\lambda^B)pu'\left(c_1^B(O)\right)\right]b_0^B = 0$.

Suppose that $b_0^A = 0$. Then, it must follow

$$\lambda^A(1-p)u'\left(c_1^A(s)\right) - (1-\lambda^A)pu'\left(c_1^A(O)\right) = (\lambda^A - p)u'[y - (1+r)d_0^A] \leq 0$$

and

$$\lambda^B(1-p)u'\left(c_1^B(s)\right) - (1-\lambda^B)pu'\left(c_1^B(O)\right) = (\lambda^B - p)u'[y - (1+r)d_0^A] \geq 0$$

what requires $(\lambda^A - p) \leq 0$, and $(\lambda^B - p) \geq 0$, what contradicts $\lambda^A > \lambda^B$. QED

The creation of the market for bets will increase (decrease) savings in $t = 0$ in the open economy if in the absence of savings or borrowing the marginal utility of consumption in the first period is smaller (greater) than the expected marginal utility of consumption in the second period. Formally, following the creation of the market for bets savings will increase (decrease) if

$$u'(y) < (>)\lambda^A u'(y + (1-p)b) + (1-\lambda^A)u'(y - pb)$$

The direction of the inequality will in general depend on the form of the utility function and the level of risk aversion. The bet increases the dispersion of consumption and its mean. A mean preserving increase in dispersion increases (decreases) savings as u”’> (<) 0 (Rothschild-Stiglitz, 1971). We refer to any resulting increase in savings as precautionary savings. On the other hand, the increase in expected consumption (from the increase in pseudo-wealth) always leads to an increase in consumption.

Proposition 1. For the quadratic utility function, $u\left(c_t^i(z_t)\right) = c_t^i(z_t) - \gamma c_t^i(z_t)^2$, savings will decrease when the market for bets is created.

Proof. It follows from

$$u'(y) = 1 - 2\gamma y > 1 - 2\gamma y - 2\gamma b(\lambda^A - p) = Eu'(c_1^A)$$

Thus, under quadratic preferences the creation of the market for bets will increase consumption at $t = 0$. This is a case in which there is no precautionary savings effect, hence the only relevant effect at the time of the creation of the market for bets is the wealth effect.

But this is not a general result. For example, for utility functions that feature precautionary savings or substitution effects, the response of savings to the creation of the market for bets may be positive. The next proposition describes sufficient conditions under which this is indeed the case.

Proposition 2: Suppose u is three times differentiable, $u' > 0$, $u'' < 0$, $u''' > 0$. Then, $\exists \lambda^* \in \left(\frac{1}{2}, 1\right)$ such that savings will increase at $t = 0$ when the market for bets is created if $\lambda^A < \lambda^*$.

Proof: Let $g(\lambda^A) = \lambda^A u'(y + (1-p)b) + (1-\lambda^A)u'(y - pb)$. Due to lemma 1, the creation of the market for bets implies $b > 0$. As agents' beliefs are symmetric, take $p = \frac{1}{2}$. Due to the strict convexity of u', $g\left(\frac{1}{2}\right) > u'(y)$ for $b > 0$. Also, as $u'' < 0$ and due to lemma 1, $g(1) = u'(y + (1-p)b) < u'(y)$. Then, due to the continuity of u', $\exists \lambda^* \in \left(\frac{1}{2}, 1\right)$ such that $g(\lambda^*) = u'(y)$. Then, savings will increase in $t = 0$ if $\lambda^A \in \left(\frac{1}{2}, \lambda^*\right)$. QED

Proposition 2 shows that given a precautionary savings motive, for a sufficiently low dispersion of beliefs when the market for bets is created the wealth effect will be dominated by the precautionary savings effect.

Note that in the analysis above we described a precautionary savings effect that counteracts the positive wealth effect. Under a utility function that allows for a certainty-equivalent representation for every risky consumption profile (as it is the case with Epstein-Zin preferences), it is then possible to isolate the risk effects and focus on the certainty-equivalent payoffs of the bet. The counteracting forces can then be described as a wealth effect and a substitution effect, as in INS. But with more general preferences, we must then focus on the actual consumption profile, and think of the counteracting forces as a wealth effect and a precautionary savings effect.

III. The certainty equivalence case

We are interested in analyzing a case in which the pseudo-wealth effect induced by the creation of the market for bets dominates the substitution effect. For simplicity, we will assume that preferences take the form of a quadratic utility function.

$$u\left(c_t^i(z_t)\right) = c_t^i(z_t) - \gamma c_t^i(z_t)^2, i = A, B$$

It is well known that the quadratic utility function cannot be globally correct, since it implies that the marginal utility of consumption becomes negative for $c_t > 1/2\gamma$. However, it will be useful for our analysis as long as we restrict the value of y sufficiently as to ensure that consumption lies in the area in which the marginal utility of consumption is positive.[20]

[20] Note that the expected wealth is bounded from above, as $d_t \geq -\frac{y}{1-\beta'}$, $y < \infty$, and the level of debt must satisfy the transversality condition. Then, as consumption will be a linear function of expected wealth, $\exists\ \bar{c} < \infty$ *such that* $c_t^i < \bar{c}$, $\forall t\ \forall i$, which implies that we could restrict γ to $\gamma < \frac{1}{2\,\bar{c}}$, ensuring that that the marginal utility of consumption is always positive.

A. Pseudo-wealth

The pseudo-wealth of agent i in period t is described by

$$PW_t^i(z^t) = \left(\lambda^i - p_t\right) b_t^i(z^t)$$

where PW_t^i is the level of pseudo-wealth of individual i in period t, and

$$b_t^A(z^t) = \begin{cases} -b_t^B(z^t) > 0, & z_j = O \ \forall z_j \in z^t \\ -b_t^B(z^t) = 0, & z_j = S \text{ for any } z_j \in z^t \end{cases}$$

Proposition 3. In equilibrium, $p_t \in (\lambda^B, \lambda^A)$.

Proof: The equilibrium condition for the betting markets is $b_t^A(z^t) + b_t^B(z^t) = 0$. By contradiction, suppose that the price of the bet in equilibrium $p_t < \lambda^B$. Then, the expected net return of betting in favor of the sunspot state will be strictly positive for both agents. Thus, $b_t^A(z^t) + b_t^B(z^t) > 0$. Similarly, if $p_t > \lambda^A$, the expected net return of betting against the sunspot state will be strictly negative for both agents, hence $b_t^A(z^t) + b_t^B(z^t) < 0$. QED

The expected present discounted value of pseudo-wealth for agent i is described by[21]

[21] As betting will be zero after the sunspot is realized, the expression for expected pseudo-wealth can equivalently be written as

$$E_t PW^i(z^t) = \sum_{j=t}^{\infty} [\beta(1-\lambda^i)]^{j-t} \left(\lambda^i - p_j\right) b_j^i(z^t)$$

where $\beta \in (0,1)$ is the discount factor (identical for all agents), and the expected aggregate pseudo-wealth is

$$\text{(PW)} \qquad E_t PW(z^t) = E_t PW^A(z^t) + E_t PW^B(z^t)$$

Proposition 3 implies that the aggregate pseudo-wealth is strictly positive before the sunspot.

B. Expected wealth and the intertemporal budget constraint

The expected wealth of each agent in period *t*, $E_t W^i$, will be composed of three parts: the expected value of the endowment the agent receives, the expected value of pseudo-wealth, and the (negative of the) debt payments that must be paid in period *t*. Then,

$$\text{(EW)} \qquad E_t W^i(z^t) = \frac{y}{1-\beta} + E_t PW^i(z^t) - (1+r) d_{t-1}^i(z^{t-1}) \; \forall i, \forall t$$

With a quadratic utility function, agent *i* faces the following intertemporal budget constraint:

$$E_t PW^i(z^t) = \begin{cases} \sum_{j=t}^{\infty} [\beta(1-\lambda^i)]^{j-t} \left(\lambda^i - p_j\right) b_j^i(z^t) > 0, & z_j = O \; \forall z_j \in z^t \\ 0, & z_j = S \text{ for any } z_j \in z^t \end{cases}$$

$$\sum_{j=t}^{\infty} \beta^j \, c_t^i(z_t) = \frac{y}{1-\beta} + E_t PW^i(z^t) - (1+r) d_{t-1}^i(z^{t-1})$$

C. Individual consumption

In this case of a quadratic utility function, the optimal consumption rule is

$$c_t^i(z_t) = y + (1-\beta)[E_t PW^i(z^t) - (1+r) d_{t-1}^i(z^{t-1})]$$

Note that at time 0, given that the outstanding debt is zero and expected pseudo-wealth is positive for both agents, $c_0^i > y \; \forall i$.

If the change in marginal utility from one period to the next is small, under a quadratic utility function each individual's consumption path will be approximately described by a random walk (Hall, 1978).[22] In every period, the bet winner (loser) will experience a positive (negative) wealth shock, and individual consumptions adjust accordingly.

D. Aggregate consumption and borrowing

Aggregate consumption is governed by the following expression:

(AC) $$c_t(z_t) = y + (1-\beta) E_t PW(z^t) - r d_{t-1}(z^{t-1})$$

Aggregate outstanding debt is given by

(AD) $$d_{t-1}(z^{t-1}) = (1-\beta) \sum_{j=0}^{t-1} E_j PW(z^j)$$

Aggregate debt will be increasing over time until the sunspot occur, and will decrease after that, in order to satisfy the transversality condition.

[22] This requires that the level of consumption in period t is sufficiently far from the bliss point $1/2\gamma$.

IV. Pseudo-wealth and consumption volatility

Proposition 4 shows that the disappearance of betting opportunities leads to a decrease in aggregate consumption that will be associated with the disappearance of pseudo-wealth. Therefore, the process of creation and destruction of pseudo-wealth will increase the ex-post consumption volatility with respect to the world in which betting does not occur (e.g. because it is prohibited or because a betting market does not exist).

Proposition 4: *At $z_t = S$, there is a decrease in aggregate consumption.*

Proof: *The result follows directly from* (PW)*,* (EW)*, and* (AC).

At the moment the sunspot occurs there will be a discontinuous decrease in aggregate expected wealth due to the disappearance of pseudo-wealth. As a result, aggregate consumption jumps downwards.

Corollary 1: *The level of aggregate consumption will be lower after the sunspot the longer it takes for the sunspot to occur, and the decrease in aggregate consumption the greater.*

The longer it takes for the sunspot to occur, the larger will be the level of aggregate debt when it occurs (cf. equation (AD)), hence the lower will be aggregate consumption in every period after the sunspot—the economy will need to generate a larger current account surplus to repay the larger external debt, hence given the constant endowment, consumption will have to fall by more.

Corollary 2: *Aggregate consumption volatility is larger when there exists a market for bets.*

With no market for bets, $c_t = 2y \; \forall t$, hence $Var(c_t) = 0$. With the market for bets, $c_t(z_t) > 2y$ as long as expected pseudo-wealth is larger than outstanding debt (a result that holds with certainty in $t = 0$) or $c_t(z_t) < 2y$ in the opposite case.[23]

The next question of interest is whether the above results imply that prohibiting bets would be optimal. Addressing this welfare question requires a criterion for dealing with heterogeneous beliefs.

Definition 1 *(Stiglitz, 1982). We say that beliefs satisfy* ***group rationality*** *if*

$\frac{1}{2}\lambda^A + \frac{1}{2}\lambda^B = \lambda$

where λ is the true probability of occurrence of sunspot.

Proposition 5: *Suppose the planner computes welfare using average beliefs and suppose beliefs satisfy group rationality. Then, under a utilitarian social welfare function, the creation of a market for bets leads to a decrease in the expected present value of welfare.*

Proof: The planner's intertemporal budget constraint at time 0 is $\sum_{t=0}^{\infty} \beta^t \, c_t(z_t) = \frac{2y}{1-\beta}$. The planner's optimal solution is $c_t^A(z_t) = c_t^B(z_t) = y$, $c_t^P(z_t) = c_t^A(z_t) +$

[23] If the resolution of one sunspot is followed by the creation of another sunspot (say also with a Poisson arrival time but being a different event than the previous sunspot), then the economy will exhibit macroeconomic fluctuations, with the longer (on average) between "crashes" and the longer the boom, the deeper the crash.

$c_t^B(z_t) = 2y \ \forall t \ \forall z_t$. The creation of the market for bets leads to $c_t(z_t) > 2y$ before $z_t = S$, and $c_t(z_t) < 2y$ afterwards. Group rationality and strict concavity of $u(\cdot)$ imply the proposition.

Proposition 5 establishes that prohibiting the bet can increase welfare from the viewpoint of beliefs that are consistent in the aggregate—as it would be the case of the beliefs of the planner that considers the true probability to be λ, given by definition 1. But such a prohibition would not increase ex-ante expected utility for agents *A* and *B given their beliefs*—indeed, both agents would be strictly worse-off ex-ante with the bet prohibition *given their beliefs.*

This proposition is a particular case of the case of "reasonable beliefs" –i.e., beliefs that are a convex combination of agents' beliefs (see Brunnermeier, Simsek, and Xiong (2014)). In fact, if the planner uses any convex combination of the agents' beliefs to compute welfare, there will always be a transfer between agents such that from the viewpoint of the planner's beliefs, it is optimal to prohibit the bet and implement such a transfer. If the planner's beliefs are closer to the beliefs of agent A (or B), then the prohibition of the bet will be accompanied by a transfer from B to A (or A to B) such that both agents are weakly better-off from the viewpoint of the planner's belief, with at least one agent being strictly better-off.

V. Extensions

Our results raise important questions regarding the effects of markets that allow for speculation in a context of heterogeneous beliefs. In spite of the simplicity of the environment we assumed, we showed that the cycles of pseudo-wealth lead to

discontinuous changes in the variables characterizing the momentary equilibrium (such as aggregate consumption) even when there are no changes in the state variables of the economy. However, this simplistic environment does not permit an analysis of other macroeconomic consequences of those discontinuous changes that arise from the resolution of a bet (or the creation of a new bet) or the fuller distributional consequences that fluctuations in pseudo-wealth could imply, which might arise, for instance, when individuals differ in ways other than their beliefs. For example, different discount factors for agents A and B would affect the dynamics of aggregate consumption. In particular, if agent A had a smaller (larger) discount factor than agent B, the non-occurrence of the sunspot would have a contractionary (expansionary) effect on aggregate consumption, as it would change the distribution of expected wealth in favor (against) of the agent with a larger (smaller) marginal propensity to consume.

More generally, fluctuations in pseudo-wealth can give rise to a variety of rich effects in more complex environments. They could, in particular, have macroeconomic effects that go beyond an intertemporal misallocation of resources. The rest of the section provides two simple examples that show how the range of applicability of the pseudo-wealth theory could be extended.

Example 1: Output fluctuations in a one sector production economy

The first example considers a one sector economy where an internationally tradable good is produced using only labor, and there are constant returns to scale:

$$y_{T,t} = l_t$$

where $y_{T,t}$ denotes the production of the tradable good that is sold at at the international price, that is constant and that we assume is equal to 1, and l_t is the amount of labor employed, all in period t.

The agents' preferences are now defined over consumption of the single good and leisure, according to $U_t^i = u(c_t^i) - v(1 - l_t^i)$, with $-v' > 0$, $-v'' < 0$. Workers receive a wage w_t per unit of labor in period t. We assume there is perfect competition in the production sector. Thus, in equilibrium $w_t = 1$.

The consumers-workers budget constraints are now

$$c_t^i(z_t) + (1 + r)d_{t-1}^i(z^{t-1}) = l_t^i + d_t^i(z^t) + \psi_t^i(z_t)b_t^i(z^t) \; \forall t \; i = A, B$$

The optimal choice of consumption and labor of the consumers-workers must satisfy the conditions

$$\frac{v'(1 - l_t^i)}{u'(c_t^i)} = 1$$

$$u'(c_t^i) = E_t^i u'(c_{t+1}^i)$$

and

$$v'(1 - l_t^i) = E_t^i v'(1 - l_{t+1}^i)$$

Maintaining the assumption $u(c_t^i) = c_t^i - \gamma {c_t^i}^2$, the creation of the market for bets will still lead to an increase in the individuals' and aggregate consumption, but will also decrease the labor supply at the fixed wage; hence it will decrease the level of employment and output in equilibrium. Following the realization of the state S, the bet's winner will decrease her labor supply and the loser will increase it. The absolute size of the negative wealth shock for the loser is larger than the absolute size of the positive wealth shock for the winner (the total negative wealth shock is the destruction of aggregate pseudo-wealth). Thus, destruction of pseudo-wealth will affect both the individuals' and aggregate labor supply: the level of employment and output will increase.

As in RBC models, the labor supply will respond negatively to positive wealth shocks (and vice versa) and this in turn will affect employment and output in equilibrium. Under different assumptions, the sign of the changes could be different. But the general point of this example is that in a context of heterogeneous beliefs in a production economy the creation of the betting market will increase the volatility of output—in this instance, pseudo wealth is the source of volatility, because it would be zero if betting were not allowed.

Example 2: Distributional effects in a two-sectors production economy

The example of this section describes an economic structure in which pseudo-wealth fluctuations lead to fluctuations in the real economy and also have distributional effects.

We now assume that the economy has two sectors, one that produces a tradable good and the other produces a non-tradable good. Production in both sectors requires labor, but production in the tradable sector also requires a factor of production that is in fixed supply, that can be interpreted as land. There is a continuum of workers of mass 1: Half of them believe the probability of occurrence of the sunspot in each period is λ^A and the other half believes it is λ^B (we refer to them as type A and type B workers, respectively). We assume perfect labor mobility across sectors.

The production function of the non-tradable good features decreasing returns to scale:

$$y_{N,t} = l_{N,t}^{\alpha}$$

where $l_{N,t}$ denotes labor in the non-tradable sector and $\alpha \in (0,1)$. A fraction $(1 - \alpha)$ of the production of the non-tradable good is kept (and consumed, not traded) by an agent that is not explicitly modeled, that can be thought of as a manager or

owner of the firm that produces the non-tradable good.[24] The rest is traded domestically at a price $p_{N,t}$.

The production function for the tradable good takes the Leontieff form,

$$y_{T,t} = \min\{l_{T,t}, X\}$$

where $l_{T,t}$ denotes labor in the tradable sector and X is a factor in fixed supply owned by a capitalist that we assume it is a foreign agent that does not spend in the domestic economy. Then, taking the price of the tradable good as the numeraire,

$$l_{T,t} = \begin{cases} X, & if\ w_t \leq 1 \\ 0, & if\ w_t > 1 \end{cases}$$

The capitalist's profit function is

$$\Pi_t = \begin{cases} (1 - w_t)X, & if\ w_t \leq 1 \\ 0, & if\ w_t > 1 \end{cases}$$

If $w_t < 1$ there will be rents in the tradable sector.

Suppose consumers-workers' preferences are described by $U_t^i = u^T\left(c_{T,t}^i\right) + u^N\left(c_{N,t}^i\right) + v(1 - l_t^i)$, with $u^{k\prime} > 0, u^{k\prime\prime} < 0, k = T, N$. Given that all workers are identical in all dimensions but on the beliefs about the probability of occurrence of the sunspot, they will all solve an identical problem at the moment the market for bets is created. Labor is mobile across sectors and the labor market is competitive.

The positive wealth shock implied by the creation of the market for bets will raise the relative price of the non-tradable good and wages in equilibrium.[25] There is a

[24] We make this assumption for simplicity. We just want to describe a situation where labor exhibits decreasing returns.

[25] The vector of equilibrium prices in this dynamic small open economy must satisfy the Euler equations for the consumption of the tradable good, the non-tradable good, and the time worked; it must satisfy the equalization between marginal rates of substitution and relative prices, $\frac{-v\prime}{u^{T\prime}} = w_t$, $\frac{-v\prime}{u^{N\prime}} = \frac{w_t}{p_{N,t}}$, and $\frac{u^{T\prime}}{u^{N\prime}} = \frac{1}{p_{N,t}}$; it must satisfy the equilibrium condition in the labor market $l_{T,t} + \left(\frac{\alpha p_N}{w_t}\right)^{\frac{1}{1-\alpha}} = \int_0^1 l_t^i di$; and it must satisfy the equilibrium condition of equalization of demand for and supply of the non-tradable good. When the wealth effect dominates the precautionary savings effect, the new

distributional effect between classes: the distribution of income in the tradable goods sector changes in favor of the workers and against the capitalist (or equivalently, the capitalists' rent decreases). When the occurrence of the sunspot destroys pseudo-wealth, the opposite occurs: as the aggregate labor supply increases, wages will fall and rents will increase. And these distributional effects could have richer macroeconomic effects in an environment that features aggregate demand externalities.

This paper has explored the consequences of pseudo-wealth and its variability in the context of the standard model with fully flexible wages and prices; but it should be obvious that large changes in aggregate demand induced by changes in pseudo-wealth can give rise to fluctuations in unemployment in models that exhibit wage or price rigidities or rigidities in changes in intertemporal prices or rigidities in the movement of labor across sectors.

While in this paper we have focused on fluctuations in pseudo-wealth that arise with the creation of new bets and new betting opportunities and the resolution of bets, there are multiple other contexts which give rise to fluctuations in pseudo-wealth. Most notably, in debt markets, creditors may believe that they will receive less than the debtors believe that they will pay; but there are many changes in the economic environment that can affect the disparity in these beliefs, and thus the aggregate level of pseudo-wealth, with many of the aggregate effects on consumption that we have detailed in this paper.

equilibrium will feature higher $p_{N,t}$ and w_t; and as analyzed earlier, the presence of pseudo-wealth will lead to external borrowing (in terms of tradable goods) in order for the Euler equation for the consumption of the tradable good to be satisfied.

VI. Conclusions

This paper has shown that, when there are differences in beliefs, the amounts that betting individuals expect to receive from other individuals may differ markedly from the amounts that these same individuals expect to pay. This disparity in (the present discounted value of) expected transfer payments we refer to as pseudo-wealth. We have noted that there can be large changes in the aggregate value of pseudo-wealth, and that these changes in aggregate pseudo-wealth can give rise to large fluctuations in consumption.

Our analysis does not need to assume that there is a well-defined distribution of probabilities that is "correct," or that such a distribution is known by the agents of the economy. Our approach seems perfectly reasonable when agents form beliefs over a one-time event. As the "rare" event only happens one time, there would be nothing to learn from its non-occurrence. It is accordingly plausible that the agents might have, and maintain, differences in beliefs. If agents don't share the same beliefs, then there is room for a bet that increases pseudo-wealth.

The theory of pseudo-wealth is complementary to other theories of macroeconomic fluctuations, but generates a set of testable hypotheses that distinguishes it from those other theories. For example, representative agent models with learning can also feature aggregate wealth misperceptions that lead to consumption booms followed by busts. However, by construction, fluctuations in those models only occur at the aggregate level; there is no betting. Hence, the opening up of a new betting market (a financial innovation) has no consequences. Instead, the pseudo-wealth theory predicts both increases in aggregate consumption volatility as well as a larger variance of consumption at the cross-section level when a betting market is created.

Unlike other theories of macroeconomic fluctuations, what matters for the pseudo-wealth theory of fluctuations is the *dispersion* of beliefs rather than average beliefs: Any changes in average beliefs would be irrelevant in our model. Besides, unlike other complementary theories, in the theory of pseudo-wealth the distribution of the individuals' consumption will change in every period before the rare event occurs even if there are no changes in the dispersion of beliefs or in average beliefs from one period to another. This occurs because in every period in which betting occurs there will be a winner and a loser, and betting will continue occurring as long as disagreement persists.

This paper is the first step of a research agenda that intends to offer a general framework for understanding situations in which large changes in macroeconomic behavior are observed together with no (or very small) changes in the state variables describing the economy. The dynamics of pseudo-wealth—its formation, dissolution, and its aggregate persistence—help explain macroeconomic volatility and gives insight into the nature of persistent booms and busts.

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