

Macroeconomics and Complexity: Inflation Theory

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INTRODUCTION

The complaints about today's macroeconomics are familiar to all. The economy is not modeled as an evolving system exhibiting emergent properties. Behavior is represented as precalculatedly optimal rather than adaptive. Actions are assumed to be preconcoiled by rational expectations rather than brought into consistency by market interaction. Heterogeneity of goods or of agents is all but completely denied.

The infinite-horizon optimizing representative agent model is not altogether representative of today's macroeconomics. We also have models with two types of mortal agents (overlapping generations) and some models with asymmetric information or externalities capable of producing coordination failures of a sort. But generally speaking these, too, tend to be subject to the same complaints.

An overview of today's macroeconomics might only too easily deteriorate into catalogue of models to which these complaints and reservations apply in varying combinations. Rather than tire you with such a litany, I will describe a set of (somewhat atypical) empirical phenomena, explain why I do not think they are handled well by current macroeconomics, and end with a few suggestions about how they might be attacked. If these suggestions were to start a critical discussion, I would find that helpful.

THE EXTREMES OF MONETARY INSTABILITY

The ensuing material is drawn altogether from my recent book with Daniel Heymann, entitled *High Inflation* [5]. His contributions to what I know about the subject are very great but he is to be absolved from any misuse or abuse that I might commit in this particular chapter.

A word or two on the perspective from which we have approached the subject of the book. In a nonexperimental field, it is often a good research strategy to pay particular attention to observational "outliers." A study of atypical or pathological cases may reveal properties of a complex system of which we would remain unaware as long as we always concentrate on well-

ordered states. In macroeconomics, this means paying particular attention to great depressions, high inflations, and (now) the transition from socialism.

The extremes of monetary instability have been my particular interest throughout my career. I find it natural to refer to such system states as "disequilibria" (or "far-from-equilibrium states") but in economics these have become fighting words in recent years, so I will avoid the usage so as to spare you any semantic or methodological digressions.

CONFRONTING "STANDARD" MONETARY THEORY WITH THE HIGH INFLATION EVIDENCE

As a start, two definitions: First, Heymann and I define an inflation as "high" when people living through it quote the inflation rate in percent per month and treat annual rates as meaningless (except for historical purposes). Inflation rates quoted in per annum terms refer to "moderate" inflations.

Second, by "standard" monetary theory I will mean the type of constructions that have dominated the monetary literature from Patinkin through Lucas and also very much dominate the two volumes of the *Handbook on monetary Economics* [2]. This standard theory "adds" money to a "real" general equilibrium model within which relative prices and the allocation of resources are determined without any reference to money or financial institutions. Modern finance theory is also done in this manner.

Applied to the problem of inflation, models of this family basically have but one channel through which money affects real income, relative prices and resource allocation, namely the so-called "inflation tax," i.e., the rate at which real balances lose real purchasing power. Like ordinary taxes, the inflation tax will induce some distortions in the allocation of effort and of resources. But the most important implication is not the oft-mentioned "shoe-leather costs of too many trips to the bank," even though in high inflations the efforts and resources devoted to economizing on cash balances are quite substantial. It is, rather, the strangulation of financial intermediation. The monetary liabilities of the banking system as a ratio to GNP may be on the order of 1/4 or 1/5 of what is normal under monetary stability. This important channel for the intermediation of saving is almost shut down, therefore.

Another point that is often missed is the regressivity of the inflation tax. The well-to-do can avoid it more easily than the poor. The point is worth making because the view that anti-inflationary policies tend to hurt the working classes, is so deeply ingrained in the English language literature.

One further comment of general nature before turning to the high inflation phenomena I want to concentrate on. In my opinion, models that attempt to explain high inflations as the result of governments calculating and implementing the "optimal" inflation tax time profile are, of limited, if any, value. The individuals that find themselves in positions of fiscal or monetary authority in a high inflation are "reaping the whirlwind" -- and almost always a whirlwind sown by others. They are not in control. Control has been lost and the intermittent attempts to stabilize are in effect desperate attempts to regain a measure of control. In the extreme, on the verge of hyperinflation, the inability to finance the public sector turns into inability to govern when not even the resources needed to maintain the proverbial "nightwatchman state" can be mustered.

We can now turn to the phenomena not predicted by standard theory.

SURPRISE NO. 1: THE SURVIVAL OF DOMESTIC MONEY

Domestic money stays in general use even at inflation rates on the order of 30+% per month. These are pretty high "tax" rates, corresponding to 2-3000% per annum taxes that would kill many a market.

Standard general equilibrium theory, in contrast, does not require money, monetary instruments, or monetary institutions. A reason for money to "hang in there" has to be invented and the most frequently used devices by which money is pasted unto the basic structure are less than persuasive. That such exceedingly costly moneys survive deserves to be listed as a surprise.

Domestic money stays in circulation, but this should not be taken to mean that it plays all the roles that we expect money to play in a country enjoying monetary stability. It is neither the only unit in which prices are quoted, nor the medium in which all transactions are settled. Instead, a triple monetary standard will develop: the markets for the stuff of daily existence deal with domestic money, but some are dollarized and others are indexed. Multiple standards of this sort give rise to numerous inconsistencies in the overall price system as, for example, when exchange rate movements change the price of all goods quoted in dollars relative to those whose prices are fixed by a (backward-looking) index.

SURPRISE NO. 2: THE UNIT OF ACCOUNT MATTERS

High inflation renders accounts kept in the domestic monetary unit virtually meaningless. No very good or generally shared substitute emerges. This, of course, is a "surprise" because in monetary general equilibrium theory the "choice of numeraire" is arbitrary [15]. But the social and legal convention of tying accounting to the unit of government issued money is not so easily changed.

The unit of account matters, most obviously, for accounting -- for measuring the "real" result of business operations. Various devices are tried. Some firms, for example, construct indices of their own input prices so as to enable them to determine whether sales proceeds would suffice to repurchase the quantities of inputs used to produce the output sold. An indicator of whether you are breaking even or not is certainly worth having, but it does not amount to a high inflation information system that would help one determine whether a firm is on its minimum cost schedule and is producing at the profit-maximizing output rate.

The inflationary economy does not gravitate toward the use of a single index as the common unit of account. Consider a contract between two firms each one of which would prefer to make future payments predictable in "real" terms as measured by its own input basket. But customers and suppliers, by definition, do not have the same input baskets. So some compromise index may have to be negotiated. But the customer in this contract is a supplier in others where different compromises have to be made, etc. So the result is a multiplication of contract indices in use. Before the 1994 *real* stabilization in Brazil, for example, some three dozen contract indices were said to be in widespread use.

Less obviously perhaps, the unit of account matters for accountability, that is, for monitoring the performance of agents in a wide variety of principal-agent relationships. This is most obvious in the public sector. When governmental budgets can no longer be drawn up for a fiscal year in a meaningful way, the executive can no longer be held fiscally accountable to parliaments, and departments or provincial and municipal governments can no longer be held accountable to the national government. Instead, everyone operates in effect under "soft budget constraints" [7].

Monetary budgeting and monetary accounts and reports are vital components of monitoring systems for all sorts of private sector principal-agent relationships as well. This includes shareholder control over corporate management.

SURPRISE NO. 3: THE DISAPPEARANCE OF INTERTEMPORAL MARKETS

American readers may recall that the very moderate inflation in the United States in time 1970s saw the disappearance of the market for 30-year bonds and the virtual demise of the 30-year fixed-rate mortgage. That moderate inflation never exceeded 15% per year.

Higher inflations will kill off markets for far shorter maturities. In Argentina in 1985, the longest nominal rate maturity was 45 days-and that was a thin market. Typical trade credit was 7 days, not the 90 days that are normal in stable circumstances.

A foreshortening of temporal perspective is "built into" the definition of high inflation from which we started. But the all but total lack of temporal depth of the high inflation economy will nonetheless qualify as a "surprise" because standard monetary and finance theory do precisely nothing to prepare us for it. Nominal contracts become risky in inflation and the more risky the higher the inflation rate and the longer the maturity. But finance theory will deny that high variance is a reason for an asset completely to disappear from the efficient portfolio. Moreover, the heterogeneity of expectations that definitely characterizes high inflations should cause more trades, not less.

It is an additional surprise that high inflations more or less kilt off stock markets as well. The old belief used to be that risk-averse people would avoid nominal placements in inflationary times and switch to "real assets, equity shares in particular. But stock markets tend to lapse into near total inactivity; no new issues are floated and the volume of trades is extremely low.¹ We conjecture that the reasons for this have to do with the accounting difficulties noted above. Corporations are in effect unable to report their earnings in a way that the market can reliably evaluate.

In brief, the kind of finance theory that prices assets in "real terms" first and introduces money later to find the "nominal scale" of those prices encounters a number of anomalies in the high inflation evidence.²

SURPRISE NO. 4: THE FRAGMENTATION OF SPOT MARKETS

Intertemporal markets disappear but spot markets fragment. Arbitrage conditions that, under monetary stability, tend to fix, for example, the relative prices of the same good sold in different locations are constantly violated in high inflations. Innumerable relative prices, that we normally do not think about because they are (more or less) constant, are instead constantly jiggling. So, despite the disappearance of intertemporal markets, the number of markets that the Hicksian aggregation theorem would oblige us to recognize is most probably multiplying.

The lack of sufficient spatial arbitrage to keep these relative prices within tight bounds is readily understandable once one takes a realistic look at the two sides of the market. On the supplier side, buying low (in one location) and selling high (in another) always takes some time. If you are not "quick enough," high inflation conditions will turn routine arbitrage into speculative transactions and highly risky ones at that. On the consumer side, the price dispersion at any one time is much greater than normal and that is an incentive to shop around. But the price discrepancies found through comparison shopping are not autocorrelated. The information gained is depreciating very

¹ In high inflation cases, the volume of trading may in fact be roughly consistent with the life-cycle theory of saving.

² Recall, also, the strangulation of intermediation discussed above

fast. Under monetary stability, this kind of everyday search activity is an investment yielding a long stream of returns. Under high inflation, the price found by visiting a store may be changing behind the shopper's back as he leaves the premises.

This fourth surprise is but one aspect of No. 5.

SURPRISE NO. 5: EXCESS RELATIVE PRICE VARIABILITY

The disappearance of markets seems to have received no attention at all in the theoretical literature³.^[3] The phenomenon of excess relative price variability, in contrast, has been the subject of a fair number of theoretical papers. The trouble, we believe, is that this literature starts from a misidentification of the phenomenon that is being modeled.

Consider two alternative interpretations -- two different ways of "stylizing the facts," if you so will. The principal difference between the two inheres in the roles in the process that they assign, respectively, to "fix-prices" and "flex-prices" (to use John Hicks' terms).

The friction interpretation blames fix-prices. What is reported as "the" inflation rate is the rate of change of some index. It is assumed that all flex-prices move in pace with the index since, by definition, they are not subject to friction. The variability of relative prices in excess of the adjustments that would be observed under monetary stability is attributed to the spasmodic and intermittent adjustment of fix-prices (Figure 1).

The friction interpretation is the one generally accepted in the literature. It fits a common preconception among economists, namely, that if anything goes wrong with the price system it must be because someone, somewhere interferes with market forces and causes some price or prices to "stick." This stickiness is usually explained by invoking so-called "menu costs," i.e., costs which the seller has to incur when he changes his price.

The turbulence interpretation sees flex-prices as becoming too volatile. The official inflation rate is taken to reflect mainly the adjustment of fix-prices while the flex-prices fluctuate around it (Figure 2).

If the friction hypothesis fits economists' preconceptions, the turbulence hypothesis goes against the grain: here the preconception is that money can be made by "buying low and selling high" so as to smooth the price paths. Any excess volatility of flex-prices ought to be smothered by profitable speculation.

Both these interpretations are too clean-cut to fit the reality. We know there is some friction, because indexation would create it even if it did not exist before. But Heymann and I believe that there is more turbulence than friction in the high inflation process.

³ The sizable and growing "missing markets" literature deals with an entirely different set of problems. "Missing markets" are imposed as a constraint on permissible trades. The problem here is that people chose not to trade in a particular maturity, for example, so that the transactions volume shrinks until it no longer pays anyone to make a market in it.

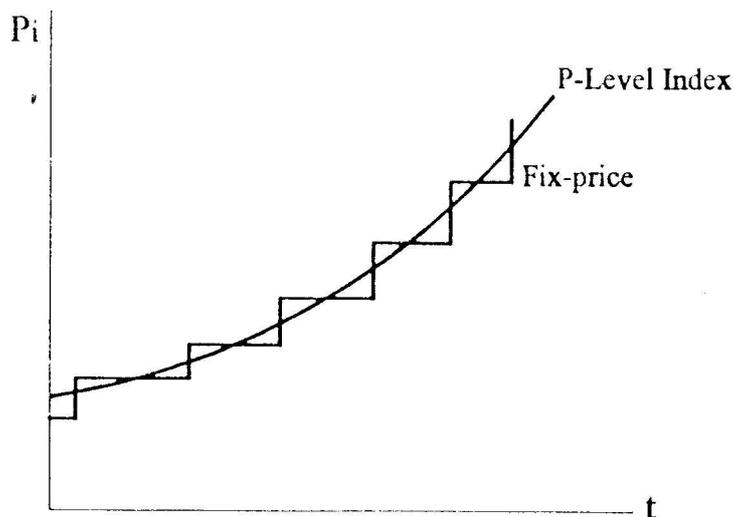


FIGURE 1 Friction hypothesis.

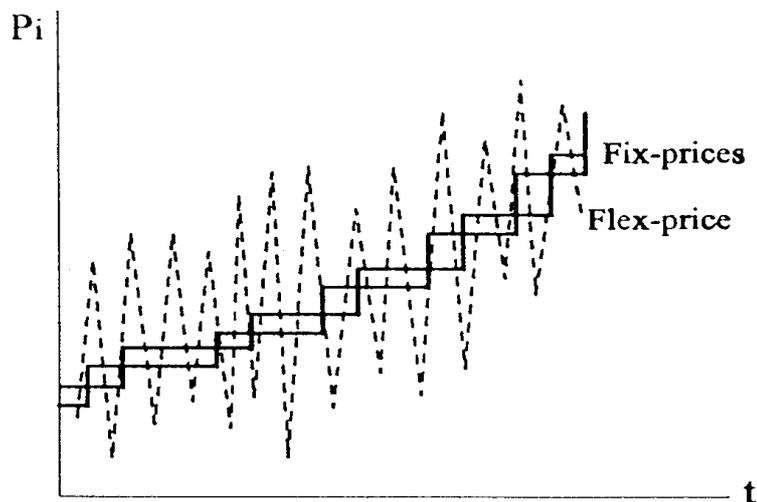


FIGURE 2 Turbulence hypothesis.

FRICION OR TURBULENCE: SOME EVIDENCE

The relationship between relative price variability (variously measured) and inflation flattens out at high inflation rates. This is consistent with the Friction theory, since the costs of maintaining a price fixed for some given period rises with the general inflation rate. There is, indeed, no doubt that the frequency with which fix-prices are revised increases with inflation. But the Friction theory implies the further prediction that the relationship should collapse altogether in hyperinflation when all prices become flex-prices.

As it turns out, the flattening out of the relationship at very high rates of inflation is in all probability a statistical artifact. The usual price index data is monthly. This is too low a frequency of observation for us really to know what is going on at high inflation rates. In his comprehensive study of more than 40 years of Mexican data, Angel Palerm [13, 14] experimented with reducing the data frequency from monthly to quarterly to annual. He found that so doing shifts the curve relating relative price variability to inflation progressively

downward and makes it flatter (Figure 3). The inference is plausible, therefore, that most of the price variability at very high inflation rates escapes notice at the monthly frequency of observation.

A careful study by Dabus [1] of the (monthly) Argentine data that had been adduced as supporting the "menu cost" theory shows the relationship between relative price variability and inflation to be monotonic. There is no tendency in these data for relative price variability to decline even in the 1989 Argentine hyperinflation episodes.

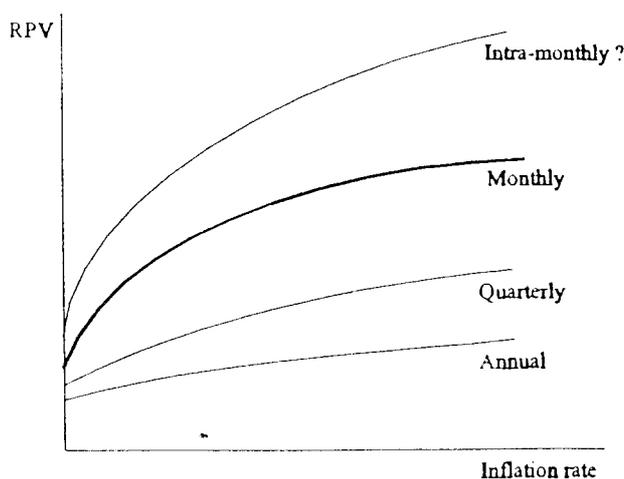


FIGURE 3 Observational frequency of relative price variability (RPV).

Some samples of higher frequency data have been collected and studied⁴. A particularly noteworthy result of Tommasi's work [6] with weekly data from a number of Buenos Aires supermarkets is his finding that nearly 1/5 (17%) of the price changes were negative. Most such price cuts are presumably made to correct for previous overshooting. Their high frequency in a period during which the inflation rate averaged above 4% per week strongly suggests turbulence, as opposed to friction, in the price formation process.

Further high frequency evidence can be drawn from the foreign exchange market. Figure 4 shows day-to-day changes of the Argentine exchange rate over the two-year period 1989-1990. The two hyperinflation episodes separated by an abortive stabilization attempt are clearly marked by the dramatic increase in the volatility of the exchange rate. The onset of hyperinflation occurs as a sharp phase transition which is an interesting problem in its own right.

Here, however, the point is simply the inferences we can draw from these data for the behavior of relative prices. Recall the "triple standard": some prices are dollarized, others are indexed, yet others remain quoted in local currencies. In hyperinflation, the number of dollarized prices increases while the number of prices that are set by reference to backward-looking indices decline. The dollarized prices will move with the extreme frequency and amplitude of Figure 4, the indexed ones will not, while local currency prices will vary widely with regard to the extent that they are or are not adjusted daily (or hourly) with reference to the latest dollar quotations.

⁴ In addition to the Tommasi study, see e.g., Lach and Tsiddon [8].

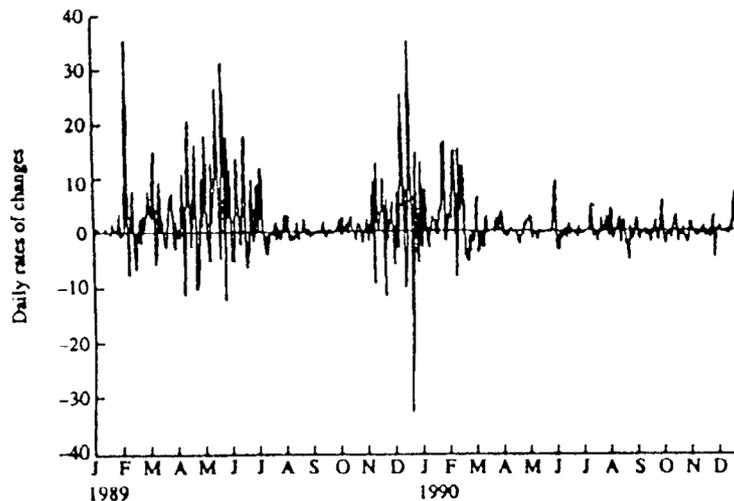


FIGURE 4. Argentine dollar exchange rate: day to day changes. Source: Heymann and Leijonhufvud [5].

TURBULENCE AND THE DISAPPEARANCE OF MARKETS

The disappearance of intertemporal markets starts in the long end, extinguishes shorter and shorter contract maturities as inflation rises, and reaches its logical limit with the outbreak of true hyperinflation when many spot transactions are affected. In the first 1989 outbreak of hyperinflation in Argentina, some store owners put out the sign "Closed for the Lack of Prices," thus declaring their refusal to sell in a situation where the prices at which they might replenish their inventories had become totally unpredictable. This phenomenon is the counterpart in the market for groceries to the simultaneous behavior of the market for foreign exchange. The extreme volatility of the exchange rate in the hyperinflation episodes of Figure 4 reflects a market from which all the big financial institutions have basically withdrawn. With the institutions unwilling to take positions on the price of tomorrow, no smoothing of the price from day to day takes place.

In the hyperinflationary limit, therefore, the general unwillingness to take intertemporal positions and the excess variability of relative prices are seen to be two aspects of the same behavioral adaptation. But the point applies not only at this limit.

Behavior representations in economics range over a spectrum of models. At one end of this spectrum, we would put the infinite-horizon (stochastic) optimization models which in recent years have become the macroeconomist's regulation equipment. At the other end, put the simplest of adaptive models, that is, models of behavior governed by feedback and relying on next to no memory and no foresight. Neither extreme is particularly palatable: one leaves no room for learning and adaptation and makes timepaths of consumption and prices far "too smooth"; the other has no vestige of deliberate rationality and produces chaotic dynamics far too

easily. Independent of theoretical fashion, the world we live in has its being somewhere away from either extreme.

The interpretation of the evidence that Heymann and I propose is that high inflations shift people's behavior away from the long term intertemporal optimizing mode toward a short-memory/short-foresight adaptive mode. The twin results of this adaptation are the disappearance of intertemporal markets and turbulence in spot markets⁵.

The turbulence interpretation of relative price variability has this to recommend it: that it leads to a unified explanation of these two phenomena whereas the friction interpretation will require an entirely unrelated hypothesis to account for the disappearance of markets. But the unified explanation also has a problem, namely, that standard theory does not contemplate-and is perhaps unlikely to countenance--such shifts in the general mode of behavior. Thus, the proposed explanation raises a deeper and more difficult question: How are we to understand the shift away from long-term intertemporal optimization toward shorter-horizon adaptive behavior?

At this stage an attempted answer has to be both tentative and speculative.⁶ What is going on at the individual level, I believe, is that agents adapt to the increased complexity of their environment by going to simpler, more flexible⁷ strategies. A strategy is more flexible if it reduces or shortens time-spanning commitments and allows the agent to reallocate his resources freely in response to information that he will receive in the future but cannot anticipate (even probabilistically) in the present. When large numbers of agents respond in this way the result, on the system level, is an even more complex environment.⁸

"Complexity" is an ill-defined term, however. What does it mean? It will not do to think of it just as "increased risk." High inflation, contrasted to "monetary stability," is not simply a mean-preserving increase in variance for an otherwise unchanged structural model. To the individual agent, increased complexity means rather that the model that he or she requires in order to predict the utility-relevant (future) outcome of a present action has more variables and requires knowledge of more parameters. This may occur, for example, as the result of a change in the monetary regime.

When the regime changes, the true specification of the novel system structure will not be known to agents. They must try to infer it. But experience with the now more complex regime is brief. The "usable memory" is short and the "useful forecasts" will be equally so.

In the standard optimization paradigm, the individual response to increased complexity is commensurably more sophisticated strategies. But this presumes that the agent understands the structure of the more complex environment as well as that of the less complex one and also that his quantitative information is as adequate to the new situation as it was to the old. When these presumptions do not hold, however, the individual response to increased complexity will be to fall back on simpler strategies, utilizing less rather than more information [3, 4].

In our context, this means (among other things) a general foreshortening of the time horizon over which commitments are presently made and an increase in the frequency with which plans are adapted in response to unfolding events. At the macro level, this change in the behavior of agents makes the system more complex, for example by making its dynamics strongly nonlinear where it may have been very "nearly linear" before.

⁵ "Turbulence" here, of course, in the literal sense of nonlinear chaotic behaviour.

⁶ For a somewhat fuller discussion, see Heymann and Leijonhufvud [5] and also Leijonhufvud [10].

⁷ I use "flexibility" in the exact sense of Hicks,⁶ pp. 37 ff.

⁸ The text leaves open the question of how this "vicious circle" of deteriorating performance originates. In general, the story will start with a government bent on spending beyond its means and using the inflation tax to do so.

RETHINKING FIX-PRICES AND PRICE "STICKINESS"

One of the lessons to be drawn from the above analysis concerns price flexibility or the lack of it. Macroeconomics, in particular, seems to have gotten totally hung up on the notion that (more) price flexibility is always a good thing and price stickiness always a source of trouble.^{9[9]}

But fix-price behavior is not generally an "imperfection" in the price system. Price setters take a position on tomorrow's price. This is elementary "smoothing" and will suffice to suppress the highest frequency price oscillations. In posting prices, sellers linearize the environment for others. When producers and middlemen are unwilling to post a price and "stick" with it for a while, ordinary agents find themselves in an environment where "fragments" of markets "hog-cycle" out of sync with each other. Such an environment poses horrendous information problems. There is almost no correlation of prices between locations and almost no autocorrelation of prices at any one location. In such complex, nonlinear settings, ordinary people find their ability to achieve the least-cost household budget or to plan ahead in a coherent manner to be "bounded."

Price setting behavior is probably an essential aspect of how "order" emerges. When tomorrow's prices have all become predictable, and day-to-day volatility suppressed, traders will look for patterns in the next highest frequency of price fluctuations and take positions in the day-after-tomorrow's prices, etc. Meanwhile, emergent autocorrelation of prices at various locations will make spatial arbitrage increasingly feasible. In this way, a coherent price system spreads across space and into the future. Under extremely favorable conditions, the economy will become sufficiently "linearized" so that markets for 30-year bonds and mortgages appear.¹⁰

The spread of the coherent price system may be viewed as a form of coevolution. Simple, profit-motivated adaptation by individual agents makes a fitness landscape emerge that is sufficiently smooth so that relatively simple adaptive behavior does not get trapped on very local optima. This is not a guarantee of a global optimum, of course. The spread of markets--of thick markets--always stops far short of Arrow-Debreu. But a quite high degree of collective efficiency becomes feasible as long as this coevolution is allowed to run its course under favorable conditions. Monetary stability, of course, is only one of the relevant conditions.

Whether it is accurate to say that the spread of markets takes the system to the "edge of chaos," I am not qualified to say. What the high inflation evidence shows (on our interpretation) is that as the disappearance of intertemporal markets edges closer to the present, irregular high frequency price oscillations are seen to appear. These are suppressed under more normal monetary conditions. We may conjecture, therefore, that the further into the future people plan and coordinate their plans in markets, the longer the wavelength of the nonlinear movements that would "survive" in the system.

ADAPTIVE BEHAVIOR AND "BOUNDED RATIONALITY"

The main conclusion of Heymann's and my book is that inflation destroys institutional arrangements and routines on which people depend in order to come close to optimizing (in some objective instrumental sense). To argue that they *depend on* stable institutions is, of course, to say that their rationality is "bounded."

Most economists heartily dislike references to bounded rationality, less perhaps because they do not know what to make of it than because they do not know what to do with it, given the economist's inherited box of tools. I have no handy recipe for how to model boundedly rational behavior either. But I want to conclude with a note¹¹ on that subject.

⁹ Thus, "menu costs" have become a welcome new toy also for those who would revive "Keynesian" economics of the price-stickiness variety.

¹⁰ Under the most favorable conditions of all--Queen Victoria on the throne-- we get consols.

¹¹ Much influenced by reading Tor Noerretranders [12], a book that deserves an English translation.

Our rationality is surely "bounded" but not necessarily by our ability to reason or to calculate. We are much better at processing large amounts of information correctly and rapidly at a subliminal level than at a consciously reasoning level. The visual cortex, for example, appears to handle on the order of 10 million bits per second whereas our conscious mind chugs along at a pace of about 50 bits per second or less [12]. But our subliminal capabilities to perform complicated tasks (such as to hit a golf ball) have to be trained and, for noninstinctual activities, conscious reasoning effort goes into the training.

Now, the proof that Arrow-Debreu plans are effectively not computable [11, 18] is theoretically interesting in itself. But the effective reason that people do not precalculate and precommit their actions in detail over long periods with multiple contingencies is not necessarily that their computing capabilities are limited, but rather that it is impossible to repeat the experiment a sufficient number of times to train yourself to do it well. In the Arrow-Debreu world, in fact, "you only go around once."

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