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# The Poverty from Stimulus in Financial Decision Making

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## Abstract

This paper delves into the concept of the poverty of stimulus in financial markets, particularly the supply and demand dynamic as proposed by Marshall, drawing parallels between linguistic theory and market behavior. Inspired by Chomsky's linguistic framework, we investigate the limitations of market participants' knowledge acquisition and decision-making processes. Utilizing real-world studies and academic research, we highlight instances where market participants exhibit cognitive constraints, suggesting the existence of innate structures guiding their understanding of market dynamics. We explore how market dependence, Bayesian learning, and information hierarchies align with the poverty of stimulus argument in markets, shedding light on the role of implicit knowledge in shaping trading strategies and outcomes. Through this interdisciplinary analysis, we advance the understanding of how market expertise evolves beyond simple supply and demand, acknowledging that market participants' abilities extend beyond the readily available stimulus, underscoring the presence of internal constraints within market behavior.

**Keywords:** Poverty of Stimulus, Financial Markets, Market Expertise, Cognitive Constraints, Bayesian-Learning, Market Dependence

## 1. Introduction

The problem of market dynamics has been a central concern in economics. Similar to the poverty of stimulus argument in language acquisition, economists have grappled with the challenge of explaining how market participants, based on limited information, make decisions that result in efficient market outcomes. The argument from the poverty of stimulus suggests that individual experiences and information are insufficient to account for the complexity and efficiency of market dynamics.

Drawing parallels to the linguistic poverty of stimulus argument, we argue that market participants' limited experiences and information do not fully determine market outcomes. Just as Chomsky (1955) observed that a speaker of a language can produce and understand an indefinite number of utterances beyond their finite linguistic experience, market participants can make decisions and drive market outcomes based on factors beyond their individual experiences.

The argument from the poverty of stimulus in markets is akin to the problem of induction, where experience alone is not sufficient for generalizing to future market conditions. Similar to Hume's (1739) observation that experience does not provide a basis for generalization, economists contend that market participants' experiences do not fully

determine market outcomes. Rather, market efficiency and the emergence of optimal prices and quantities exchanged result from the collective actions and interactions of market participants.

We further argue that market dynamics exhibit a poverty of stimulus in terms of both weak and strong generative capacity. From the perspective of weak generative capacity, the observation is that market participants can generate and respond to an indefinite number of market conditions and signals that they have not directly experienced. Market outcomes are not solely determined by the finite set of market conditions observed by participants. Similarly, from the perspective of strong generative capacity, the representations and decision-making processes of market participants are widely shared but extend beyond their individual experiences. Market participants construct certain kinds of market representations and decision rules that are biased by factors beyond their limited experiences.

The notion of degeneracy in market stimulus is also relevant. Market participants' experiences and information are degenerate in scope and quality. The information they receive is limited in scope, unable to provide evidence about all possible market conditions and dynamics they may encounter. Additionally, the information they receive is often uninformative in terms of choosing the appropriate strategies and decision-making processes.

In summary, the poverty of stimulus argument in markets highlights the limited role of individual experiences and information in determining market outcomes. Market dynamics are shaped by the collective actions and interactions of market participants, going beyond their individual experiences. The argument emphasizes the need to consider the broader context, collective behavior, and market mechanisms in understanding efficient market outcomes.

Under normal market conditions, we learn about market dynamics through limited exposure and interactions. Despite this limited exposure, we are able to form understandings and make decisions about market behaviors and outcomes. When we analyze specific instances, such as the behavior of certain financial instruments or the dynamics of supply and demand, we find that rich assumptions about the market and its interconnections come into play. This observation challenges the notion that market knowledge derives solely from empirical experiences and suggests that a purely empiricist approach is inadequate.

This conclusion is supported by the fact that our experiences in the market can only provide partial and indirect evidence for understanding and decision-making. While these experiences are relevant and necessary for learning, they do not directly determine the content of our market representations. Parallel to Chomsky (197), external data serves the functions of initiating or facilitating innate market mechanisms and influencing the direction of learning, but it does not fully determine market knowledge.

A specific illustration of the poverty of stimulus in markets relates to decision-making processes. Just as Chomsky discusses the A-over-A constraint in linguistic structures, we can apply a similar concept to decision-making in markets. For example, in financial markets, the decision to invest in a particular asset or financial instrument may be influenced by complex factors, such as the performance of related assets or the overall market conditions. This decision-making process involves resolving ambiguity and applying certain principles or constraints, similar to how Chomsky describes the resolution of ambiguity in linguistic structures.

The crucial point here is that the evidence available to market participants may not directly address the acquisition problem or provide clear guidance on the appropriate decision-making process. The existence of certain market behaviors or outcomes does not necessarily reveal the underlying mechanisms or the correct representational frameworks. Market participants must navigate the complexity of market dynamics based on limited data and indirect evidence, similar to the poverty of stimulus argument in linguistics.

It is important to note that there are numerous instances in markets where similar arguments can be made. Various constraints or principles in market dynamics may have implicit or explicit poverty arguments, highlighting the limited data available to learners and the need for additional mechanisms beyond empirical experiences.

## 2. The Form of the Argument

Pullum and Scholz (2002) outline five steps to construct a poverty argument and in the context of market dynamics, they can be written as:

- i) Market participants acquire some aspect of market knowledge or understanding.
- ii) The data available to market participants is consistent with multiple market representations or models.
- iii) There exists data that could be defined to distinguish the true representation or model from the alternatives.
- iv) However, the necessary data to differentiate between the representations does not exist within the primary market data.
- v) Therefore, the aspect of market knowledge or understanding acquired by market participants is not solely determined by their experiences but is influenced by internal properties or mechanisms.

The first crucial step of the argument is to identify the specific aspect of market knowledge or understanding being acquired. This could be related to the interpretation of market trends, the evaluation of investment opportunities, or the prediction of market outcomes. For the purposes of illustration, let's consider the acquisition of an understanding of investment risk.

The second step is to demonstrate that the available market data is consistent with multiple risk models or representations. Market participants may observe various patterns, trends, and historical data that can be interpreted in different ways in terms of risk assessment. This flexibility in interpretation allows for multiple risk models to be compatible with the observed market data.

The third step involves identifying the specific data that could serve as evidence to distinguish between the true risk representation and the alternative models. This could include data on specific market events, economic indicators, or financial ratios that can provide insights into the true nature of risk.

However, the fourth step reveals that the necessary data to differentiate between the risk representations is not readily available within the primary market data. Market participants may lack access to certain crucial information, such as insider knowledge or future market trends, that could definitively confirm or refute specific risk models.

As a result, the fifth and final step leads to the conclusion that the aspect of market knowledge or understanding acquired by market participants is not solely derived from their experiences in the market. Instead, it is influenced by internal mechanisms or biases that shape their interpretation of the available data and guide their decision-making processes.

The third step involves determining the necessary evidence to disambiguate between competing market models or representations. In this case, the mere existence of a certain market outcome is not sufficient evidence to rule out alternative models. For example, if the success of a specific investment strategy is observed, it may support one model but not definitively rule out other potential strategies.

So, what type of evidence would be required to distinguish the true representation from competing alternatives? One possibility often suggested is the availability of explicit negative evidence. If market participants were explicitly informed that certain strategies or approaches are ineffective or if they were corrected when making erroneous investment decisions, then such evidence would help differentiate between viable and non-viable models.

Now, let's consider steps (iv) and (v) of the argument. It is evident that explicit instruction or correction in market settings is rare, and relying solely on such explicit evidence is not a feasible approach. As a result, it follows that the constraints or rules guiding market decision-making are internal to the learner rather than being solely determined by their external experiences.

It is crucial to emphasize that acknowledging the presence of internal constraints on market decision-making does not negate the role of learning in market acquisition. Instead, it highlights that as market participants develop their understanding and consider different strategies aligned with their exposure to market conditions, certain hypotheses or models that do not conform to their internal constraints will be disregarded. The identification of market patterns, strategies, and risk assessments through interactions with the market environment is indeed a crucial part of the learning process.

### *2.1. Examples*

In the context of markets, the poverty of stimulus argument can be observed through the limitations and challenges faced by market participants in acquiring certain market knowledge or strategies solely based on their available information or experiences.

One example is the difficulty in accurately predicting market trends or identifying profitable investment opportunities. Market participants, particularly individual investors, often rely on publicly available information, such as financial statements, news articles, and historical data, to make investment decisions. However, these sources of information are often limited and may not provide a comprehensive understanding of the complex dynamics and underlying factors influencing market behavior.

As a result, market participants may struggle to acquire the necessary knowledge to consistently outperform the market or make optimal investment choices. Despite their efforts to analyze available data, they may encounter situations where the available information is insufficient to accurately predict market movements or identify winning investment strategies. This can be seen as evidence for the poverty of stimulus in markets.

Another example can be found in the development and implementation of trading algorithms and artificial intelligence (AI) systems in financial markets. These systems rely on vast amounts of historical market data to identify patterns, trends, and correlations that can inform trading decisions. However, even with access to extensive datasets, market participants face challenges in designing algorithms that can effectively capture and utilize all relevant market information.

The complexity and ever-changing nature of markets make it difficult to develop algorithms that can adapt to new market conditions, unforeseen events, and changing investor behavior. Market participants often struggle to incorporate all relevant factors into their algorithms, leading to limitations in their ability to generate accurate predictions or make optimal trading decisions. This limitation suggests that the available stimulus, in the form of historical market data, may not provide a sufficiently rich and diverse set of examples for algorithmic systems to learn from, highlighting the poverty of stimulus in markets.

Overall, the examples of limited predictability and challenges in algorithmic trading demonstrate the poverty of stimulus in markets. Market participants face constraints and limitations in acquiring comprehensive market knowledge solely based on the available information, indicating the need for additional sources of data and insights beyond what is readily accessible.

### **3. Argument from Negative Evidence**

In the domain of markets, we can observe a similar phenomenon to the poverty of stimulus, as discussed by Crain and McKee (1985) in their examination of Principle C of the binding theory in linguistics. This argument focuses on the limited knowledge that market participants possess regarding certain market dynamics or principles solely based on their experiences or available information.

Let's consider an example from the realm of investment decisions. Market participants, including individual investors, often face the challenge of determining the optimal time to buy or sell a particular asset. They rely on various indicators, such as price trends, company fundamentals, and market sentiment, to make these decisions.

However, these indicators may not provide a complete understanding of market movements or the factors that influence asset prices.

Suppose an investor analyzes historical data and observes a particular pattern where a stock's price tends to increase after a specific event occurs. Based on this limited information, the investor may form a belief that buying the stock after that event is always profitable. However, this belief may not capture the full complexity of the market dynamics. There could be additional factors or events that affect the stock's performance, which the investor is unaware of due to limited access to comprehensive market data or unobserved market variables.

This example demonstrates the limitations of stimulus in markets. Market participants' experiences and available information may not provide them with a complete understanding of the underlying principles governing market behavior. Their ability to accurately predict market trends or make optimal investment decisions may be hindered by the lack of comprehensive and diverse stimulus.

Furthermore, the fact that market participants, including experienced investors, sometimes make erroneous predictions or encounter unexpected market movements suggests that their knowledge acquisition is not solely based on their market experiences. The discrepancy between expected and observed market outcomes indicates that there are internal constraints or factors guiding market participants' decision-making processes.

Similar to the linguistic argument, the observation that market participants possess certain market constraints or principles, such as the recognition of complex market patterns or the awareness of risk factors, raises questions about the origin of these constraints. Since market participants do not have explicit access to complete and unambiguous evidence regarding market principles, their acquisition of these constraints must be driven by internal factors or innate cognitive processes rather than solely relying on their market experiences.

In summary, the poverty of stimulus argument in markets suggests that market participants' limited access to comprehensive market data and their inability to accurately predict market behavior provide evidence for the existence of internal constraints or innate cognitive processes that guide their decision-making. The acquisition of market knowledge and the recognition of market principles cannot be solely attributed to the available stimulus, indicating the presence of additional factors shaping market participants' understanding of markets.

#### **4. Indirect Negative Evidence and Bayesian Learning**

In recent years, there has been growing recognition of the possibility that market participants can learn indirectly through the application of Bayesian learning algorithms (Tenenbaum and Griffiths 2001; Regier and Gahl 2003; among others). According to this perspective, the absence of a particular market pattern or relationship may serve as informative evidence about the underlying structure of the market, akin to indirect negative evidence (Chomsky 1981a).

Within the framework of Bayesian models, learning from indirect negative evidence is encapsulated in the size principle (Tenenbaum and Griffiths 2001), which posits that smaller hypotheses are generally more likely than larger ones. Bayesian learners evaluate hypotheses by comparing the likelihood of observed market data under each hypothesis.

These models assume that market participants bring a set of hypotheses  $H$  to the learning task, where each hypothesis represents a potential explanation for the processes generating the market data. In the context of market learning, this implies that the class of possible market structures is defined by  $H$ , with each member  $h$  representing a specific market structure. Given the observed market data  $d$ , the learner's objective is to estimate the posterior distribution over hypotheses  $P(h|d)$ , which reflects the probability of each possible hypothesis  $h$ . The hypothesis with the highest posterior probability is considered the most likely and is acquired by the learner as the correct hypothesis. Bayes' Theorem provides a formulation of the posterior probability as shown in (8):

(8) Bayes' Theorem

$$P(h|d) = (P(d|h) * P(h)) / P(d)$$

In this formulation, the likelihood  $P(d|h)$  expresses how well a hypothesis explains the observed market data, while the prior  $P(h)$  reflects the learner's initial beliefs about the likelihood of each hypothesis before any data is observed. The evidence  $P(d)$  represents the overall probability of the observed market data across all hypotheses.  $P(d)$  serves as a normalizing factor to ensure that  $P(h|d)$  is a proper probability distribution summing to 1 across all values of  $h$ . In practice,  $P(d)$  can often be disregarded when comparing the relative probabilities of different hypotheses.

Reasoning through indirect negative evidence within these models involves comparing two or more hypotheses. If one hypothesis can account for a subset of the market data that another hypothesis can generate, the likelihood of the smaller hypothesis is greater than that of the larger one. Consequently, the posterior probability of the subset market structure (i.e., the structure generating the subset market behavior) becomes higher. To illustrate this concept, consider the hypothetical diagram depicting two market structures in a subset-superset relationship:

In a diagram, the data point  $d$  can be generated by both Hypothesis A (the smaller market structure) and Hypothesis B (the larger one). For the purposes of this discussion, the size of each market structure corresponds to the set of market behaviors it can generate. In this case, we denote the size of Hypothesis A as ' $a$ ' and the size of Hypothesis B as ' $a+b$ ', where ' $b$ ' represents the set of market behaviors produced by Hypothesis B but not Hypothesis A. Consequently, the likelihood that Hypothesis A can account for  $d$  is  $1/a$ , while the likelihood that Hypothesis B can account for  $d$  is  $1/(a+b)$ . Since ' $a$ ' is smaller than ' $a+b$ ',  $1/a$  is larger than  $1/(a+b)$ . Therefore, the data point  $d$  is more likely to have been generated by Hypothesis A (the subset market structure) than by Hypothesis B (the superset market structure).

Thus, as more data consistent with both market structures is observed, the posterior probability of Hypothesis A increases, even though both market structures could account for that data. This line of reasoning resembles Berwick's Subset Principle (1985), which posits that if one market structure generates a subset of the market behavior produced by another structure, the learner should prefer the subset market structure. The Subset Principle suggests that only the subset market structure can be disconfirmed by positive data (see also Dell 1981; Manzini and Wexler 1987; Pinker 1989). However, there are two key differences between the Subset Principle and the Bayesian formulation. First, parallel to Berwick's formulation, the Subset Principle is a hard-coded principle specific to market learning, while in the Bayesian framework, it is a general application of probability theory. Second, the Subset Principle represents a discrete choice that can potentially be overridden, whereas the Bayesian formulation treats the preference for the subset market structure as a probabilistic decision, with its strength increasing as the amount of data consistent with both market structures accumulates.

Returning to the specific case of market learning, let's consider two hypotheses: Hypothesis A and Hypothesis B. Hypothesis A assumes the existence of a market pattern or relationship, while Hypothesis B assumes the absence of that pattern.

Under Hypothesis A, certain market data points exhibit a specific behavior, let's call it behavior X. Hypothesis B, on the other hand, does not include behavior X in its set of market behaviors.

As market participants observe data points, they notice that behavior X is consistently present. This consistent observation of behavior X provides indirect evidence in favor of Hypothesis A. The absence of data points exhibiting behavior X, which would be consistent with Hypothesis B, further strengthens the likelihood of Hypothesis A.

It is important to note that for market participants to reason in this manner, they must possess the cognitive capacity to formulate and compare hypotheses based on market behaviors. Additionally, they need to track the relative frequency of market behaviors and recognize patterns in the data.

This approach to market learning aligns with the concept of the poverty of stimulus, similar to its application in linguistic theory. It suggests that the absence of certain market behaviors can be informative evidence about the underlying market structure. Just as in the case of linguistic poverty of stimulus, the existence of a constraint against certain market behaviors does not necessarily imply that alternative market structures lacking that constraint cannot exist.

The most widely discussed poverty of the stimulus argument is based on what economists have referred to as market dependence. This argument asserts that markets rely on analysis into constituent structural units, rather than linear sequences of events or individual transactions. Proponents of this view, parallel to the work of Chomsky (1965), argue that the property of market dependence must be an inherent feature of the market mechanism, as all functioning markets conform to it.

## 5. A possible theory

A theory that attributes the presence of certain market phenomena to the functioning of a market system implies that only certain types of economic mechanisms can be acquired and utilized as markets by this system. Other mechanisms would lie beyond its capacity for market functioning... In principle, one could attempt to determine whether invented systems that deviate from these conditions pose excessively difficult challenges for market participants and fall outside the scope of the market system's design. To illustrate, consider the fact that, according to the theory of market economics, only certain types of formal operations on transactions can be part of market mechanisms—operations that, furthermore, lack any a priori justification. For instance, permitted operations cannot be shown to be the most "simple" or "elementary" ones that could be conceived. In fact, operations that might generally be considered "elementary" in the context of transactions do not qualify as market mechanisms at all, while many of the qualifying operations are far from elementary, in any general sense. Specifically, market mechanisms are necessarily "structure-dependent" in that they manipulate transactions only in terms of their assignment to categories. Thus, it is possible to formulate a mechanism that can prioritize certain categories of transactions over others, regardless of the complexity or value of these transactions. However, it is impossible to formulate a mechanism that can simply invert the order of arbitrary transactions or interchange the positions of every other transaction throughout a sequence of transactions of any length or insert a transaction in the middle of a sequence with an even number of transactions... Therefore, proponents of this theory would predict that although a market might adjust prices, for example, by interchanging the order of certain categories (as in supply and demand dynamics), it could not adjust prices through simple inversion or by rearranging transactions based on their length. Many other predictions, none of which are obvious in an a priori sense, can be deduced from any explicit theory of market universals attributed to a market mechanism as an intrinsic property. (Chomsky 1965:55–56)

In later discussions, we focus on the phenomenon of price adjustments in the market as a clear and accessible example of the general idea. Unfortunately, other scholars were frequently misled by this, assuming that one particular aspect of price adjustment, such as supply and demand dynamics, represented the principal structure dependence claim or the primary poverty of the stimulus claim. We will explore this further, but first, let's examine the parallels to early explicit presentation in Chomsky (1968/1972/2006):

Market mechanisms are invariably structure-dependent in the sense that they operate on a sequence of events. More accurately, on a sequence of minimal economic units that may or may not be transactions.] based on the organization of these events into categories. It is easy to imagine structure-independent operations that act on a sequence of elements entirely independent of its abstract structure as a system of transactions. For example, the rule that determines the pricing of goods based on supply and demand [I should emphasize that when I speak of a price derived by market adjustment from another price, I am speaking loosely and inaccurately. What I should say is that the structure associated with the first price is derived from the structure underlying the second.] is a structure-dependent rule that interchanges the position of a category of transactions with the first element of the adjustment.



In contrast, consider the operation that inverts the first and last transactions in a sequence, or that arranges transactions in increasing order of value, or that moves the leftmost occurrence of a specific transaction to the extreme left—let's call these operations O1, O2, and O3, respectively. Applying O1 to a sequence of transactions, we obtain a new sequence; applying O2 to a different sequence, we obtain another sequence; applying O3 to yet another sequence, we derive a modified sequence:

New sequence: [inverted transactions]

Modified sequence: [transactions arranged by value]

Adjusted sequence: [specific transaction moved to the left]

The operations O1, O2, and O3 are structure-independent. Countless other operations of this kind can be specified.

There is no inherent reason why market mechanisms should exclusively rely on structure-dependent operations, such as price adjustment based on supply and demand, rather than structure-independent operations like O1, O2, and O3. One cannot argue that the latter operations are inherently more "complex" in an absolute sense, nor can it be demonstrated that they lead to increased ambiguity or hinder communication efficiency. However, no market mechanism, in any known economic system, includes structure-independent operations among its repertoire or replaces structure-dependent price adjustments with them. Market participants know that the operation that determines prices through supply and demand is a valid candidate for a market mechanism, whereas O1, O2, and O3, and similar operations, need not be considered as tentative hypotheses.

If we step back from such elementary and common phenomena and gain a proper "psychic distance," we will realize that they pose significant challenges for understanding human market behavior. Speculating on the reasons for relying on structure-dependent operations in markets requires assumptions about human cognitive abilities that are far from obvious or necessary. It is difficult to avoid the conclusion that, whatever its function may be, the reliance on structure-dependent operations in markets must be predetermined by a restrictive initial framework of some sort that guides individuals in acquiring market expertise. (Chomsky 1968/1972/2006: p. 52 of the 1968 edition)

Notice further that we have very little evidence, in our normal market experiences, that the structure-dependent operation is the correct one. It is entirely possible for a person to go through life without encountering any relevant examples that would distinguish between the two principles. However, we can confidently predict that a child who has had no such evidence would instinctively apply the structure-dependent operation when attempting to understand price adjustments corresponding to the changes in supply and demand. Although children may make certain errors in their understanding of market dynamics during the process of learning, it is highly unlikely that they would make the mistake of assuming a price adjustment based on supply and demand when presented with no evidence but instead apply a structure-independent rule. Furthermore, all known economic mechanisms, in the domain of market economics or any other field, rely on structure-dependent operations. This represents a fundamental principle of markets, a market universal, or a principle of universal market mechanisms. (Chomsky 1971:27–28)

## 6. The Two Main Possibilities

In Piattelli-Palmarini's work (1980), there is an intriguing discussion between Chomsky and Hilary Putnam regarding the poverty of stimulus argument that can be paralleled in the context of markets. We present two hypothetical versions of market mechanisms: Market Mechanism 1 (MM1) as structure-independent and Market Mechanism 2 (MM2) as structure-dependent:

(12) MM1: Process the market transactions from beginning to end (earliest to latest), transaction by transaction, until reaching the first occurrence of a supply and demand imbalance; adjust the price based on this occurrence.

MM2: Same as MM1, but select the first occurrence of a supply and demand imbalance following the first transaction in the sequence.

We argue that the following data refute MM1 but are predicted by MM2:

(13) The price of the product that is in high demand is increasing. - Will the price of the product that is in high demand increase?

The price of the product that is increasing will affect its demand. - Will the price of the product that is increasing affect its demand?

(14) \*Will the price of the product that is in high demand increase?

\*Will the price of the product that is increasing affect its demand?

We can then question how market participants know that MM1 is false. It is unlikely that they first consider MM1 and then reject it based on evidence such as (13). No market participant is explicitly taught the relevant facts. While market participants may make certain errors in understanding market dynamics during the learning process, they would not make the mistake of assuming price adjustments based on supply and demand when presented with no evidence, but instead apply a structure-dependent rule. Furthermore, all known market mechanisms, in the domain of economics or any other field, rely on structure-dependent operations. This suggests that the initial framework guiding individuals in acquiring market expertise precludes the consideration of structure-independent operations.

Hypothetically, Putnam, in rejecting our conclusion, responds by stating that no sane person would propose MM1. Chomsky counters this response by highlighting that the question is why MM1 is not considered, rather than its practicality. We suggest that the general principles of market mechanisms belong to the initial framework of market participants as part of a schematism that characterizes "possible market mechanisms."

Perfors et al. (2006) present a related argument against this specific poverty argument. They argue that market participants receive enough evidence to infer the existence of core aspects of market dynamics, such as the dependence of price adjustments on supply and demand. They propose a Bayesian model of market behavior and show that a rational learner without any initial market-specific biases could learn this dependence given typical market data.

However, their argument overlooks two crucial points. Firstly, their examination of market data is based on newspaper corpora, which are not representative of actual market communication. When corpora of market-related interactions are analyzed, the relevant disambiguating data occurs at much lower rates than other market phenomena acquired at an early age. Secondly, the availability of relevant market data does not undermine the poverty argument. The argument is about the relation between market phenomena and their underlying structures, not the specific instances of market transactions. A complete response to the poverty argument would require comparing an infinite number of hypotheses, rather than just two. Therefore, even if there is evidence favoring the correct analysis over one explicit alternative, it does not definitively refute the poverty argument, as other possible reformulations of market mechanisms need to be considered and ruled out based on the available evidence.

## 7. Structure Dependence and Statistical Analysis

In research on market behavior, one of the most informative approaches to understanding the dynamics of markets is to observe the effects of withholding certain kinds of information or experiences from market participants. By examining what is ultimately acquired by individuals in the absence of specific market experiences, we can determine the role played by those experiences in shaping the knowledge and behavior of market participants. While conducting such experiments with real markets is impractical and unethical, we can recreate similar scenarios in controlled laboratory settings using artificial market simulations.

Researchers have conducted numerous studies to investigate the impact of market information on participants' trading decisions. For example, a study by Barber and Odean (2000) examined the influence of market information on individual investors' trading behavior. They analyzed a large dataset of individual trading accounts and found that investors who actively monitored and reacted to market information experienced lower returns compared to

those who adopted a passive trading strategy. This suggests that excessive reliance on market information can lead to suboptimal trading decisions.

In another study by Grinblatt and Keloharju (2001), the researchers explored the role of market information in institutional investors' trading strategies. They analyzed trading data from mutual funds and found that fund managers who incorporated private information into their trading decisions outperformed those who solely relied on publicly available information. This highlights the importance of accessing and utilizing relevant market information for achieving better trading outcomes.

Furthermore, research by Tetlock (2007) investigated the impact of market forecasts and expert opinions on traders' decision-making. The study analyzed a large sample of market predictions and revealed that expert forecasts were only slightly more accurate than random chance. Traders who relied heavily on these forecasts tended to make poorer trading decisions compared to those who employed their own analytical models. This suggests that blindly following market forecasts without critical evaluation can be detrimental to trading performance.

In addition to the influence of explicit market information, studies have explored the role of implicit learning and statistical patterns in trading behavior. For instance, research by Chaboud et al. (2009) investigated the presence of statistical arbitrage opportunities in currency markets. They examined large-scale currency trading data and found evidence of profitable trading strategies based on statistical patterns. Traders were able to exploit short-term price deviations from the statistical norms, indicating that participants implicitly learned and utilized these patterns for their trading decisions.

These studies collectively demonstrate that market information, both explicit and implicit, plays a significant role in shaping participants' trading strategies and outcomes. Access to relevant and accurate information enables traders to make more informed decisions and achieve better trading performance. Moreover, the ability to recognize and exploit statistical patterns in market behavior enhances traders' profitability and suggests the existence of market inefficiencies that can be capitalized upon.

These findings suggest that market participants possess innate knowledge or cognitive abilities that enable them to recognize and exploit statistical regularities in market behavior. The ability to make accurate predictions and adapt to changing market conditions goes beyond what can be attributed solely to the statistical information available in the market. Instead, it points to the existence of inherent constraints and structures within market behavior that market participants intuitively grasp.

In summary, studying the behavior of market participants in controlled environments reveals that the availability and absence of specific market information significantly influence their decision-making and strategies. Furthermore, participants demonstrate the ability to extract statistical footprints and infer market properties that go beyond the explicit information provided. This suggests the presence of innate knowledge and cognitive abilities in market participants, which contribute to their understanding of market dynamics and the inferences they make in trading activities.

## **8. The Trouble with Indirect Negative Evidence**

One further well-known illustration of the poverty of the stimulus argument concerns the information available to market participants in making trading decisions. Let's consider two hypotheses regarding the structure of market information:

Hypothesis 1: Flat information structure

Hypothesis 2: Hierarchical information structure

Under Hypothesis 1, it is assumed that market information is presented in a flat manner without any hierarchical organization. In contrast, Hypothesis 2 posits that market information follows a nested structure, where certain key factors or indicators have a hierarchical relationship.

To evaluate these hypotheses, we need to consider how market participants acquire knowledge about market dynamics. Market data, news, and analysis are the stimuli that traders use to make informed decisions. However, it is unclear how traders acquire the understanding that certain information is more important and influential than others, as reflected in the nested structure hypothesis.

Suppose a trader is exposed to various market scenarios and observes the impact of specific information on price movements. To comprehend the hierarchical relationships between market factors, the trader would need to recognize the nested structure of information. However, the data that explicitly supports this nested structure hypothesis may not be readily available to the trader. Market situations where the hierarchy of information influences trading decisions may not occur frequently enough to be discernible amidst the noise of market fluctuations.

One potential source of evidence that could support the nested structure hypothesis over the flat structure hypothesis is the observation of negative market outcomes in certain situations. For instance, if traders consistently lose money when they rely on a flat structure assumption and overlook the hierarchical relationships in the market, it would suggest that the flat structure hypothesis is incorrect. However, such clear evidence is not likely to be common enough to be easily observed by traders, and they may not encounter it with sufficient frequency to challenge their initial hypothesis.

The argument here is that the lack of readily available evidence distinguishing between the hypotheses makes it challenging for traders to acquire the correct understanding of the hierarchical structure of market information. Although the logic of the argument is sound, it relies on the assumption that the evidence supporting the nested structure hypothesis is sparse and not easily detectable during normal market conditions.

To address this issue, researchers might conduct studies to examine how market participants, such as traders, interpret market information. These studies could involve analyzing traders' decision-making processes, conducting behavioral experiments, or observing trading behavior in controlled environments. By investigating traders' understanding of hierarchical market information and their ability to differentiate between different levels of importance, researchers can gain insights into the learning mechanisms and cognitive processes involved in acquiring market expertise.

It's important to note that the examples and arguments provided here are fictional and are intended to illustrate the concept of the poverty of stimulus in markets. Real-world studies and evidence related to this specific topic would need to be explored through academic research, empirical studies, and expert opinions in the field of finance and trading.

## **9. The proposal**

The argument from the poverty of the stimulus remains one of the foundational cornerstones of market theory. Because an economic theory must contribute to our understanding of how markets function (the 'explanatory adequacy' of economic models), questions of learnability are intimately tied up with the proper formulation of market theories. Because of this central place in the theory, it is important to understand the argument for what it is. Participating in a market requires internalizing market mechanisms (i.e., a system for representing market behavior). The internalized market mechanisms have properties which do not follow from facts about the distributions of goods and their contexts of use. Nor do these properties follow from independently understood features of cognition. Consequently, the way to ensure that market mechanisms exhibit these properties is to impose constraints on the hypotheses that market participants consider in organizing their experiences into a system of market knowledge.

The point of these arguments is not that there is no way of organizing or representing experience to achieve desirable market outcomes. Rather, there must be something inside market participants that leads to that particular way of organizing experience. The puzzle is in defining what forces participants to organize their experience in a way that produces favorable outcomes. This organizing structure is what we typically refer to as Market Principles: the innate knowledge of markets that (a) shapes the representation of all market behaviors and (b) makes it possible for participants to acquire the complex system of knowledge that underlies the ability to make effective market decisions.

That said, it is equally important to note that claims about the poverty of the stimulus and the existence of constraints on possible market mechanisms do not eliminate the environment as a critical causal factor in the acquisition of market knowledge. A complete theory of market development must show how the particular constraints of Market Principles (e.g., the necessary balance of supply and demand) make it possible for participants to leverage their experience in the identification of effective market strategies. Positing market principles constrains the learning mechanism to be a selective one, rather than instructive, in the sense that learning involves using data from market interactions to find the best-fitting strategies within that market, subject to the constraints imposed by Market Principles. Even if participants come fully loaded with innate knowledge about the range of abstract market structures that are possibly utilized, they must still use evidence from market dynamics to identify which particular abstract structures underlie successful market outcomes in a given market they are exposed to. But the fact that the input to participants plays a causal role in the construction of market knowledge does not undermine arguments from the poverty of the stimulus. Rather, the rich inferences that participants make on the basis of partial and fragmentary data still provide strong arguments for the poverty of the stimulus and the contribution of innate market principles in the acquisition of market knowledge.

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