

# Understanding Currency Market Dynamics Through Constructal Theory: A Managerial Perspective

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## ABSTRACT

*Over the years, numerous scientific models have been applied to foreign exchange markets in an attempt to better understand them and manage their associated risks. The challenge has been finding a model that is robust enough to capture the dynamic nature of these markets and yet still easily understood by managers. This paper suggests that constructal theory can effectively explain the flow of information in currency markets in much the same way it explains the flow of water in a river. The validity of this research offers the potential for better risk management and enhanced decision making by international managers and investors.*

**Keywords:** Currency; Currency Markets; Constructal Theory

## INTRODUCTION

Most international managers have a difficult time understanding how currency markets move and how those movements affect management decisions (Baird, 2006). As the business world becomes more complex and interconnected, the application of theories and models from various fields of science has increased. This has been especially true as we strive to understand human behavior since all businesses are a compilation of the people they employ. Carroll (2006) used the new science of axiology to objectively measure how a person makes decisions; Williams (2002) found memetics, the science of memes (a unit of cultural material propagated by an imitation process), had the potential to better understand customer behavior; Goleman (1995) popularized the psychological concept of emotional intelligence which led to a plethora of research showing how it could enhance organizational performance and leadership; Shelton and Darling (2004) examined conflict via chaos and quantum mechanisms, suggesting that conflict played a valuable role in continuous improvement initiatives; Wheatley (2007, 2008) developed new leadership models, derived from living systems and complexity science, that suggested people self-organize into networks based on interdependent relationships; and Pryor and Bright (2007) applied chaos theory to career development noting that networks and connectivity could have a profound impact on the way we view business.

For those who have studied the foreign exchange market it is obvious that human behavior has an impact on the markets. As Harvey (1993) suggested, markets are social institutions that serve to organize and guide human behavior. He went on to say that studies of the foreign exchange market would be more productive if they were based on this premise (Harvey).

Not surprisingly, the dynamics of currency markets are difficult for most managers because the conceptual models for currency markets are incomplete. The most commonly used model, Purchasing Power Parity (Frankel & Rose, 1996) is easy to understand but it is not uniformly supported by data (Jacobson et al., 2008; Parsley & Wei, 2007; Chaieb & Errunza, 2007; Engel, 1999) and ignores all the shorter term movements in currencies managers must deal with (Rogoff, 1996). The other popular and easy to understand model, the International Fischer Effect, is a derivation of Purchasing Power Parity and thus similarly challenged. There are a number of other models that attempt to explain currency movements such as the GARCH (Bollerslev, 1990), Neural Networks (Chen & Leung, 2005; Yao & Tan, 2000), and Random Walk (Meese & Rogoff, 1983) but none are comprehensive, simple and broadly understood.

A more holistic understanding of the dynamics of currency markets would allow managers to make better decisions about when to hedge currency market risks or avoid particular transactions entirely because the potential costs are greater than the potential profits. The challenge is to go beyond simply understanding foreign exchange prices and

endeavor to understand how rates are determined without regard for how they fit our preconceptions (Harvey, 2001). Constructal theory offers the opportunity to understand that the perceived complexity of the currency market actually displays the same treelike design of all things that flow.

## CONSTRUCTAL THEORY

It is common to find concepts, developed in one scientific field, that show relevance and are eventually transferred to other areas of scientific inquiry. The theory of relativity for example, was developed in astrophysics but was eventually adapted as a mental model to help explain the relative nature of measurements across many of the physical and social sciences.

Constructal theory, developed as a theory in geology, is beginning a similar transition into the social and biological sciences (Merkx, 2007). According to constructal theory, every living system and sector of society is a conglomerate of flows that morph over time in order to flow more easily; creating patterns that are not complicated (Bejan, 2008). Research on human expectations and their affect on currency markets found they were not random but exhibited a pattern that was explicable (Harvey, 2002). The tree-like patterns of constructal theory reflect the natural flow of fluid, heat, and information (Bejan, 2008) which makes it the ideal model to explain the interconnectivity of human behavior and foreign exchange markets as one system that is dynamic rather static.

Therefore, constructal theory has many relevant implications for understanding how currency markets operate and evolve. Constructal theory was originally developed to explain the dynamic ways in which drainage systems develop into streams and rivers. The theory states (Bejan, 1997):

For a finite-size flow system to persist in time (to live) it must evolve in such a way that it provides easier access to its currents.

Constructal theory shows how a flow system (e.g., river basin, blood vessels) that is endowed with sufficient freedom to change its configuration, exhibits patterns that provide progressively better access routes for the currents that flow (Bejan, 2007). Since currency flows are among the principle determinates of exchange rates, models should represent these flows explicitly (Osler, 2006).

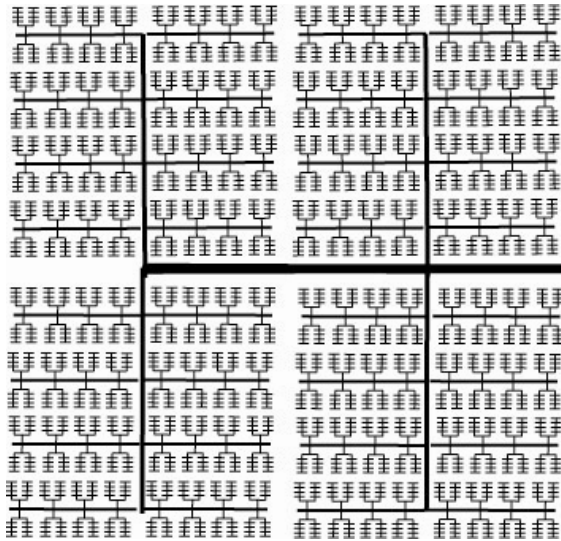
Constructal flow theory then provides optimization techniques that allows calculation of optimal performance for the system and predicts the model the system will continue to move towards. Constructal theory also allows for imperfections in the system and can predict how an optimizing system will construct around them. Most importantly constructal theory describes how a system constantly adjusts to changes in system or environment conditions, thereby providing a dynamic model of system behavior.

The initial application of constructal theory, to understanding river beds, provides a good foundation for understanding the theory. Ask the question "if you have an area on which you pour water and you expect that water to exit the area at a single point, what is the optimal number of channels to move the water?" According to constructal theory, the natural pattern of streams and rivers will always move towards that optimal route given the constraints of the system.

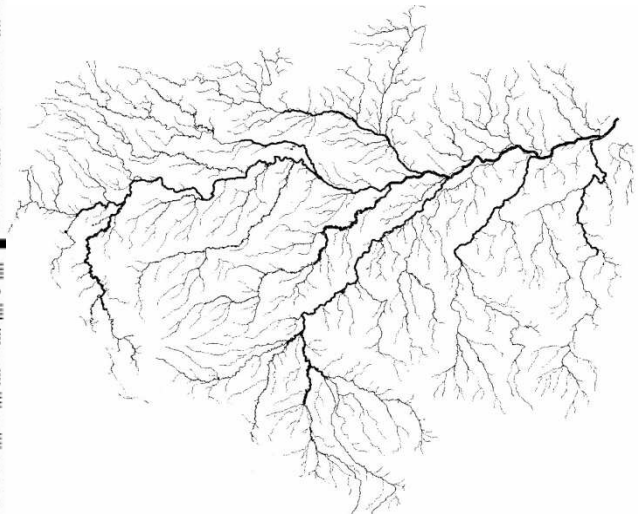
Since the optimal route for the water can be calculated, the channels needed form a hierarchical branching system such as that shown in Figure 1. With area slope, immovable rocks and other imperfections added, the channels usually take on the more common appearance of most rivers, like the picture of the Amazon River shown in figure 2. This efficient river pattern of hierarchical branching is very common in nature and constructal theory explains why.

Constructal theory is gaining popularity in other fields because it provides an orientation to more clearly understanding dynamic systems. It explains that even inorganic systems try to reach maximum efficiency given their constraints. Applications of constructal theory then provide a method to calculate maximum efficiency in an area and thus predict future movements in an existing systems development.

Constructal theory is now the bedrock theory in understanding natural drainage systems and has been extended to such fields as flight dynamics, running and swimming (Bejan, 2007, p. 24-26) but as previously noted, constructal theory can also be applied to many social sciences, such as urban design (Lorente, 2007), human traffic flows (Reis, 2007), air traffic systems (Perin, 2007) and even organizational structure (Morrone, 2007).



**Figure 1: Theoretically Optimal Hierarchical Branching Channel**



**Figure 2: The Amazon River**

### **APPLYING CONSTRUCTAL THEORY TO CURRENCY MARKETS**

Constructal theory is an ideal model to enhance our understanding of currency markets. First, it is important to understand how free floating currency exchange rates are determined. Currency exchange rates, for floating currencies, are a market balance of supply and demand for two currencies (Shamah 2003 p. 45). In itself, that is simple. The difficult part of determining exchange rates, however, is in determining the supply and demand of each of the currencies at any given time.

Understanding the supply and demand for a currency is where constructal theory adds the greatest benefit. Supply and demand in a market are primarily driven by information available to market participants (Tivenga & Chiofi, 2004). The flow of information into a market is very similar to the flow of water into a river. Water entering a river may come from a large tributary near the mouth of the river, which will reach the mouth of the river quickly and have a large impact on its flow, or it may come from a smaller tributary farther up the river, which will reach the mouth more slowly and have a smaller impact on the flow when it reaches the river mouth. Similarly, some information is very high priority and closely monitored by currency markets (e.g. central bank target interest rates) so it has a fast and substantial effect on market demand for a currency. However, other information is lower priority and not closely monitored so it may have a slow, cumulative effect when other information is added but has little effect on its own (e.g. a small, closely held companies earnings report). If mapped, the speed of flow and perceived importance of information to markets looks very similar to a river bed.

Consider Figure 3. It shows a single currency “river” of information flowing into currency markets. There are many information sources that feed the currency market information flow but have little impact on their own. For instance, an earnings report from a small company will probably have little impact on the market but as it gets aggregated into industry and national earnings reports, these small reports eventually have an impact on the market although it is slower and less impactful on the overall flow. Other information, such as announcements by a country’s central bank, politicians or major business executives has an immediate significant effect on the overall currency market.

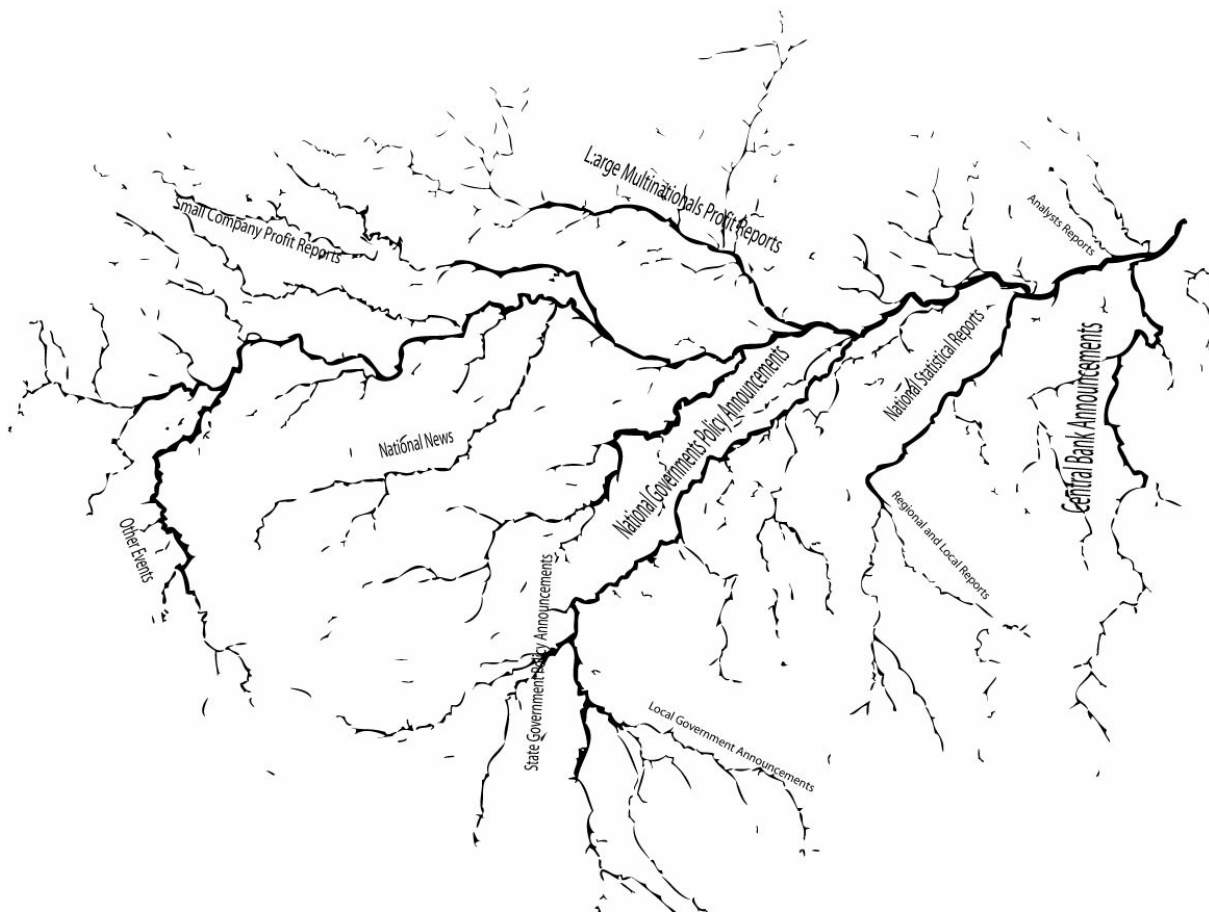
Many financial traders, who use currencies to store value, and commercial traders, who use currencies as a medium of exchange, find it a necessity of survival to understand currency markets (Osler, 2006). Therefore, they do their best to monitor the various sources of information in the marketplace while judging its impact based on the size and timing of each information source. An individual manager or trader could never expect to outguess the market given the thousands of information sources and their differing timing affects. Only a large trading company might be able to set up a system that monitored many of the information flows and the affects of their timing. Even the largest firms would be challenged to continually trade on a model while also constantly adjusting their market strategies based

on the importance and timing of current news reports. Some of the harder to understand currency models such as Neural Networks attack the adjustment issue (Chen & Leung 2005) but by necessity then need to adjust after the fact rather than predicatively.

### ADDING CONSTRUCTAL DYNAMICS

The importance of constructal theory, to understanding currency markets, is not just in showing how information flows to markets but also in providing insight about how those flows will change over time. Constructal theory suggests there is a maximum efficiency for information flow that the existing information flow is trying to reach. The system therefore constantly adjusts to try and make information flow closer to the optimal.

In practice adapting to a dynamic model requires understanding that no fixed market model will ever function for a long period of time because each information flow will keep trying to reach its optimal level. As technological, social or political breakthroughs occur, some information flows will be better able to utilize these advantages. For example, a company could introduce an easy to use technology that allows weekly sales of any company to be posted to the Internet and Italy's government might require all companies over a particular size to regularly post weekly sales. That would create substantially better information flows on Italian large company sales. The improved information and speed of information would increase the importance of Italian large company sales in estimating demand for the Euro. Such adjustments to the flow of information occur regularly to markets so any attempt to create a fixed model will ultimately lead to failure.



**Figure 3: Loose Model of Currency Market Information Flow**

The advantage to understanding constructal dynamics is that it shows how changes in the importance of information and flow rates are not random events as it is treated in Neural Networks. It is not possible to know exactly

which information sources will change at any given time, but it is possible to predict which direction they will change. Over time, the flow rates will become more important as they move closer to the optimal model, which means they will become a faster and more reliable source of information.

Knowing the direction of model changes will provide financial model builders the ability to better predict the aggregate affect of information environment changes. For managers constructal theory provides a more robust tool and for model builders it can be used to predict the long-term direction of financial markets. This will result in markets responding faster and faster to smaller and smaller changes in information, which may create more fear than comfort for many managers. Overall, however, this model will be extremely helpful. Although information flowing from higher up the system will increase in importance as it become more rapidly available, it won't replace the importance of the information flows further down the system. The entire system will be closer to an optimally flowing "river." The river will not go away. The information flow models through the river will move faster but more predictably. In fact, the more optimally it flows, the better predictions one could make of the direction and speed of currency changes. The only obstacles that will prevent a very reliable prediction model are events and changes that restrict the flow of information in new ways.

### **RESTRICTIONS TO FLOW**

As stated, constructal theory grew from studying water flows through rivers. Yet no river follows an optimal course for draining an area. In fact, constructal theory says a river will always be moving towards that optimal flow, suggesting it will never reach it. The reason the river will never reach its optimal flow pattern is that elevation differentials, rocks, trees, leaves and all sorts of other elements block the water flows from attaining their optimal flow. Over time the water may erode away rocks and other impediments to improve efficiency but ultimately new impediments usually develop as the old ones deteriorate.

Restrictions similarly play an important part in keeping currency markets from reaching their optimal information flows. Some restrictions are easy to identify and understand, such as a country's currency regulations. Other restrictions, such as a cultural tendency to understate or overstate individual accomplishments are much harder to observe making it more difficult to understand how they affect company earnings reports and ultimately currency markets. Understanding the flow of information to currency markets ultimately becomes an exercise in understanding the restrictions that constrain those information flows.

A working constructal model of currency markets, therefore, requires substantial attention be paid to the restrictions that would prevent the model functioning optimally. Building "rocks" into the model based on country regulations, technology, cultural restrictions, or other impediments that restrict information flow is critical. These "rocks," however, do offer an advantage. Although they keep the model from moving to its optimum, they provide somewhat fixed markers while the model is adjusting. For example, one cannot assume a government's accounting regulations will always stay the same. While they are in place, however, they provide a basis for comparisons across companies within the country that would not otherwise be possible.

### **CONCLUSIONS**

Constructal theory provides a mechanism for predicting changes in flow systems. Since currency markets are a system of information flows, understanding constructal theory could help a manager understand and anticipate changes that occur in currency markets. This understanding is critical to an international manager's ability to appreciate the ambiguity in currency market predictions and at the same time have a better tool to reduce them. For instance, the foreign monetary exchange is critical to financial traders whose careers are built on trading currencies. Since dealers make their livelihood from trading currencies, the accuracy of interpretation of exchange-rate determination can make or break their career (Osler, 2006). For companies who do business outside of their home country, hedging currencies allows them to do business more efficiently. More transparency has the potential to reduce exchange rate volatility, which can make risk more manageable for companies and traders alike.

Harvey (1993) noted that international trade and investment is a positive force. He goes on to say that international trade and investment is critical because it provides employment, promotes useful allocation of resources, and encourages a tolerance of other cultures (Harvey). Since exchange rate volatility discourages trade and investment by adding another cost to doing business internationally, it should be avoided when possible (Harvey, 1993, 2001). In an era that looks to greater cooperation and interdependence between countries, facilitation of a more efficient currency exchange model is important.

Since other theories have not provided a robust model for foreign currency exchange, constructal theory offers financial and corporate entities an opportunity to embrace a model that has the potential to reduce risk, manage cost more effectively, and increase control of foreign investment returns. This alone seems like an appropriate reason to explore the merits of constructal theory and the foreign exchange market.

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