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From Tulips to Monstera: Rational Bubbles in Aesthetic Assets

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Abstract

Inspired by Tulip Mania, this paper theoretically studies rational bubbles in non-standard assets which give aesthetic pleasure instead of dividends. Rational bubbles can exist when new investors are drawn in by the optimistic coordinated beliefs, make the price to rise, and push away all aesthetic consumers. Using the trading data of variegated Monstera market in Thailand between 2020-2021, the empirical results confirm the existence of bubbles and its boom-bust episode.

Keywords: rational bubbles, boom-bust episode, asset pricing, regime-switching, Tulip Mania, variegated Monstera

1 Introduction

If we trace back the history of asset price bubble origin, Tulip Mania of 1636-1637 stands at its beginning. As an alien species from Turkey to the Western Europe, the huge popularity started to spread all among the wealthy. There were many different varieties of tulips at the time but the particular hype was upon the rare ones that gave unique coloured patterns. For example, the pricy Semper Augustus which produced a beautiful flame-like pattern on the white petals was very hard to find due to the reason, unknown at that time, that it is actually infected by the virus. The price of a single tulip bulb rose sharply and hit the peak level which was equivalent to buying a decent house. Later, the price dropped down more than 90% and the craze ended. Most scholars believe that this Tulip mania is the first bubble-boom-bust episode ever recorded.

After the Tulip mania, many boom-bust episodes have been witnessed- such as the South Sea Bubbles in early 1720s, the Japanese Real Estate Bubbles in late 1980s, Thai-baht Tom Yum Kung Crisis in late 1990s, the Dot-com Bubble in early 2000s, and the US Subprime Housing Bubble in mid 2000s. However, these big bubble events are only associated with either the financial asset or the real estate. In the literature of rational bubbles developed since Tirole (1985), it is standard for the asset to act as a store of value that does not directly earn holders any utility but indirectly benefits them from its dividends and capital gain. Subsequently, the bubble is defined as the excess price over the fundamental level which in turn is defined as the sum of all discounted dividends from the asset.

Unlike a Lucas' tree from Lucas (1978) where his tree bears some other consumption good as dividends, people love tulips because of their own aesthetic contribution. Although they do not give any dividend, their fundamental bases on the pleasure they provide. The question is whether rational bubbles can really exist in this class of assets, or Tulip Mania is just a misunderstood history.[1] This paper proposes the theoretical framework for the bubble in this newly-classified *aesthetic assets*. Moreover, we present the empirical evidence of bubbles in a plant with the greatest hype during 2020-2021, namely the variegated Monstera.

Monstera is a genus of 52 currently-recognized species leaves originated from Central and South America- see Cedeno-Fonseca et al (2020, 2021). This foliage plant is best known for its beautiful perforate green leaves and has been commonly used for gardening and home decoration. With similar tropical weather condition, Southeast Asia has become the main region which grows Monstera for the commercial purpose and exports to the world market. This green Monstera is easy to find and to be taken care of. However, its variegated version is rare and much more mesmerizing.

In early 2020 which is the beginning of the COVID-19 pandemic, there was a global boom in the variegated foliage plant markets including Monstera. In Thailand which is the main supplier of Monstera worldwide, the domestic market for variegated Monstera is heated. The official recorded example is the price of a single Monstera with the "Mint" variegation hit 1.4 million baht in June 2020. Some experts believe that the new peak is still being reached.[2] This amount of money can afford a good house in Thailand which put variegated Monstera hype similar to Tulip Mania. In comparison, both tulips in 1630s and variegated Monstera in 2020s are both relatively rare (limited supply compared to considerable demand), and both belong to the class of aesthetic assets mentioned above.

The main contribution of this paper is on the theoretical formulation of how to understand rational bubbles in the price of aesthetic goods. Our model shows that the rational bubble can only exist when there is no consumers of aesthetic goods left in the market. This can happen when new investors flood the market due to optimistic coordinated beliefs. Subsequently, the increase in price pushes away all consumers and bubbles emerge. This regime-switching system from the fundamental to the bubbly regime helps explain both Tulip Mania and Thailand's variegated monstera boom. In addition, our empirical results confirms the existence of the variegated Monstera bubble and its boom-bust episode.

The literature of rational bubbles is built upon the asset with specific features. As gathered in the surveys of Scherbina (2013) and Martin and Ventura (2018), the first feature is that asset can give dividends and these dividends in turn define the fundamental value of this asset.[3] Most works focus on assets with no intrinsic value which means they give no dividend and hence their fundamental value is zero just like money.

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[1] Garber (1989, 2000), Thompson (2006), and Szpiro (2011) are skeptical over whether Tulip Mania is bubble phenomenon or can be justified by the fundamentals. However, Van der Veen (2012) argues that the bubble indeed did occur.

[2] Source: https://www.tnnthailand.com/news/socialtalk/81362/

[3] The fundamental price is normally defined as the sum of all discounted future dividends. Alternatively, Froot and Obstfeld (1991) purposes the fundamental price to be the function of the current dividend due to myopia among investors.

Another common feature is to have an infinite life span. The infinitely-lived horizon of asset is crucial of bubble emergence as reselling, or speculating, is the main incentive for bubble purchase.[4] This holds true for the aesthetic asset in this paper. In spite of the fact that plants and pets are not precisely durable goods, here we still consider them as assets because of their self-reproduction. That is, people do not buy only a plant but also its future offspring.

Lastly, the standard asset does not appear directly in the utility function. In other words, it is assumed that people do not consume this asset or aesthetically enjoy holding it. Even though the asset is the real estate, the literature of rational bubbles tends to assume away its function of sheltering, but emphasize only on the properties of generating rents, being a store of value, and collateralizing loans- for example, see Kiyotaki and Moore (1997), Martin and Ventura (2016), and Luengaram and Thepmongkol (forthcoming). A few, but famous, works like Matsuyama (1990), who models the bubbly money in the utility function, do have people directly enjoy holding these assets. Yet, there is no study addressing that this feature should take part in determining the fundamental price.

The paper is organized as follows. Section 2 officially defines aesthetically assets and outline the theoretical fundamental model. The model is extended to allow bubbles in Section 3. Section 4 describes the conjecture of how Thailand's variegated Monstera bubbles emerge and evolve. Section 5 presents an empirical support and further discussion. At last, Section 6 concludes the paper.

2 Aesthetic Assets and the Fundamental Economy Setup

We start our theory by precisely defining what is an aesthetic asset. Motivated by Tulip Mania and the Thailand's boom of variegated Monstera during 2020-2021, Definition 1 scopes the asset in concern according to four stylized characteristics.

Definition 1

The aesthetic asset must satisfy following conditions;

- It appears in the utility function directly.
- It does not give any dividend.
- It is either durable or reproducible.
- It tends to incur some cost of maintenance or reproduction.

According to Definition 1, many goods can be aesthetic assets including plants, animals, gold, brand-named accessories, collectibles, and so on. For the sake of storytelling, we decide to use the term variegated Monstera to represent the entire class of aesthetic assets from here on.

[4] The bubble in finitely-lived asset is only possible when there is an asymmetric information problem in the market as suggested by Allen, Morris, and Postlewaite (1993) and Conlon (2004).

Our theory bases on the simple Overlapping Generations economy populated with two types of agents: consumers and investors. Consumers live only for one period and enjoy the consumption good as well as the aesthetic good, namely variegated Monstera. That is, the utility function is given by $\frac{\tilde{c}_t^{1-\theta}}{1-\theta} + \gamma \ln \widetilde{m}_t$ where $\tilde{c}_t$ and $\widetilde{m}_t$ are the individual demands for consumption good and variegated Monstera respectively, $\gamma > 0$ is the preference parameter weighting utilities gained from variegated Monstera to consumption good, and $\theta^{-1} > 0$ is the elasticity of intertemporal substitution of the consumption good. Each consumer is endowed by a constant $\tilde{e}$ in every generation. Denote p_t as the price of variegated Monstera in term of consumption good. The consumer's utility maximization problem is written below.

$$\max_{\tilde{c}_t, \widetilde{m}_t} \frac{\tilde{c}_t^{1-\theta}}{1-\theta} + \gamma \ln \widetilde{m}_t$$

subject to

$$\tilde{c}_t + p_t \widetilde{m}_t = \tilde{e}$$

The corresponding optimality condition is as follows;

$$\frac{p_t \widetilde{m}_t}{(\tilde{e} - p_t \widetilde{m}_t)^\theta} = \gamma \tag{1}$$

where $p_t \widetilde{m}_t = \tilde{V} \in (0, \tilde{e})$ is uniquely determined for all t.

Unlike consumers, investors live for two periods and do not enjoy any aesthetic good. That is, the utility function is given by $\frac{c_{1,t}^{1-\theta}}{1-\theta} + \beta \frac{c_{2,t+1}^{1-\theta}}{1-\theta}$ where $c_{1,t}$ and $c_{2,t+1}$ are the individual demands for consumption good of the young investor at time t and the old investor at time $t+1$ respectively, and $\beta \in (0,1)$ is the discount factor. Each investor is endowed e_1 when young and e_2 when old. We assume that e_2 is sufficiently small so that the young investor needs to save for the future. In order to store the value across time, young investor invests in variegated Monstera, reproduce and sell them when old. The variegated Monstera production function of the old investor at time $t+1$ is defined by $Ak^\alpha m_t$ where m_t is the individual purchase of the young investor at time t on variegated Monstera, $k > 0$ is the variegated Monstera reproduction capital (we assume to be exogenous here for simplicity) and $A > 0$ is a constant production parameter. The investor's utility maximization problem is written below.

$$\max_{c_{1,t}, c_{2,t+1}} \frac{c_{1,t}^{1-\theta}}{1-\theta} + \beta \frac{c_{2,t+1}^{1-\theta}}{1-\theta}$$

subject to

$$c_{1,t} + p_t m_t + k = e_1$$

$$c_{2,t+1} = e_2 + p_{t+1} A k^{\alpha} m_t$$

where the optimality condition is derived as follows;

$$\frac{p_t m_t}{(e_1 - k - p_t m_t)^{\theta}} = \frac{\beta p_{t+1} A k^{\alpha} m_t}{(e_2 + p_{t+1} A k^{\alpha} m_t)^{\theta}} \tag{2}$$

We assume that the populations of both types grow at the constant same rate $1+n$ and hence the constant demographic proportion between consumers and investors is fixed at φ over time. Denote $\widetilde{N}_t$ and N_t as the numbers of consumers and investors of generation t. Therefore, we have $N_{t+1} = (1+n)N_t$ and $\widetilde{N}_t = \varphi N_t$. We can now write the variegated Monstera market-clearing condition as follows;

$$\widetilde{N}_t \widetilde{m}_t + N_t m_t = N_{t-1} A k^{\alpha} m_{t-1} \tag{3}$$

Substitute Equation (3) in Equation (2) to get the equilibrium equation below.

$$\frac{p_t m_t}{(e_1 - k - p_t m_t)^{\theta}} = \frac{\beta(1+n)(p_{t+1} m_{t+1} + \varphi \widetilde{V})}{[e_2 + (1+n)(p_{t+1} m_{t+1} + \varphi \widetilde{V})]^{\theta}} \tag{4}$$

where $p_t m_t = V_t \in (0, e_1 - k)$ is variegated Monstera purchase value of each investor at time t. Lemma 1 characterizes the steady state of V_t from Equation (4).

Lemma 1

There always exists a unique steady-state investor's variegated Monstera purchase value $V_f \in (0, e_1 - k)$.

Proof

Consider the Left-Hand Side (LHS) and the Right-Hand Side (RHS) of Equation (4). Trivially, $LHS|_{V_t=0} = 0$, $\lim_{V_t \to e_1 - k} LHS = \infty$ and $dLHS/dV_t > 0$. For the right-hand side,

$$RHS|_{V_t=0} > 0$$

$$RHS|_{V_t=e_1-k} \in (0, \infty)$$

$$\frac{dRHS}{dV_{t+1}} = \frac{\beta(1+n)\left[e_2 + (1-\theta)(1+n)\left(V_{t+1} + \varphi\widetilde{V}\right)\right]}{\left[e_2 + (1+n)\left(V_{t+1} + \varphi\widetilde{V}\right)\right]^{1+\theta}}$$

$$\frac{d^2RHS}{dV_{t+1}^2} = -\frac{\theta\beta(1+n)^2\left[2e_2 + (1-\theta)(1+n)\left(V_{t+1} + \varphi\widetilde{V}\right)\right]}{\left[e_2 + (1+n)\left(V_{t+1} + \varphi\widetilde{V}\right)\right]^{2+\theta}}$$

Given $\theta \in (0,1]$, we have $dRHS/dV_{t+1} > 0$ and $d^2RHS/dV_{t+1}^2 < 0$. As a result, there must be only a single cut between LHS and RHS determining $V_f \in (0, e_1 - k)$.

Given $\theta > 1$, the characteristics of RHS depend on the value of V_{t+1} as follows;

$$V_{t+1} \in \left[0, \frac{e_2}{(\theta-1)(1+n)} - \varphi\widetilde{V}\right] \Longrightarrow \frac{dRHS}{dV_{t+1}} \geq 0 \; and \; \frac{d^2RHS}{dV_{t+1}^2} < 0$$

$$V_{t+1} \in \left(\frac{e_2}{(\theta-1)(1+n)} - \varphi\tilde{V}, \frac{2e_2}{(\theta-1)(1+n)} - \varphi\tilde{V}\right] \Rightarrow \frac{dRHS}{dV_{t+1}} < 0 \; and \; \frac{d^2RHS}{dV_{t+1}^2} \leq 0$$

$$V_{t+1} \in \left(\frac{2e_2}{(\theta-1)(1+n)} - \varphi\tilde{V}, e_1 - k\right] \Rightarrow \frac{dRHS}{dV_{t+1}} < 0 \; and \; \frac{d^2RHS}{dV_{t+1}^2} > 0$$

which imply the shape of RHS to be a single-peak domelike curve or a part of it. Regarding the increasing convex LHS curve, this resulting shape of RHS also guarantees a unique steady state $V_f \in (0, e_1 - k)$. Q.E.D.

Next, we will show that there cannot be any bubble in the price of variegated Monstera at the steady state when there still exists any aesthetic demand from consumers. Note that the asset price bubble ($p_{b,t}$) is defined as the difference between the market price (p_t) and the fundamental price where the fundamental price ($p_{f,t}$) is the sum of discounted stream of asset's dividends. Here, aesthetic pleasure from possessing variegated Monstera can be the dividend as illustrated in Tirole (1985). Therefore, the variegated Monstera price can be broken down by recursively forward iterating Equation (4) as follows;

$$p_t m_t = \varphi\tilde{V} d_t + d_t p_{t+1} m_{t+1} = \underbrace{\varphi\tilde{V}(d_t + d_t d_{t+1} + \cdots)}_{p_{f,t} m_t} + \underbrace{\lim_{T\to\infty} \left(\prod_{i=1}^{T} d_{t-1+i}\right) p_{t+T} m_{t+T}}_{p_{b,t} m_t} \qquad (5)$$

where $d_t = \left[\frac{\beta(1+n)(e_1-k-p_t m_t)^\theta}{[e_2+(1+n)(p_{t+1}m_{t+1}+\varphi\tilde{V})]^\theta}\right]$

Proposition 1

As long as $\varphi\tilde{V} > 0$, there cannot exist any bubble at steady state.

Proof

At steady state, Equation (3) implies that $d_t = d = V_f/\left(V_f + \varphi\tilde{V}\right) \in (0,1)$ for all t given $\varphi\tilde{V} > 0$. Thus, the fundamental and bubble values in Equation (5) can be calculated at steady state as follows;

$$p_{f,t} m_t = \varphi\tilde{V}(d + d^2 + \cdots) = V_f = p_t m_t \Rightarrow p_{b,t} m_t = 0$$

which proves the proposition given the unique existence of V_f in Lemma 1. Q.E.D.[5]

Proposition 1 points out that bubbles cannot emerge in the price of aesthetic goods as long as there still consumers who truly demand them for their own aesthetic pleasures. In other words, the only way to create bubbles is to allow only investors to participate in the market which makes $\varphi\tilde{V} = 0$. In the next section, we purpose the mechanism that possibly brings about the bubbly equilibrium.

5 In Appendix, we show that for $\varphi\tilde{V} > 0$ there also cannot be bubble in any cycle equilibrium.

3 Bubbly Economy: Regime-Switching System

Here, we follow the setup of the previous setup except on modification: there is the other aesthetic good that is perceived by consumers as a perfect substitute for variegated Monstera. In particular, we look at this good as an outside option for consumers as its price is given from outside the economy and its supply is perfectly inelastic. Let $\hat{p}_t > 0$ and $\widehat{m}_t$ be respectively the exogenous price and the consumer's endogenous demand of this outside option. The utility maximization of the consumer is now re-written below.

$$\max_{\tilde{c}_t, \widetilde{m}_t, \widehat{m}_t} \frac{\tilde{c}_t^{1-\theta}}{1-\theta} + \gamma \ln(\widetilde{m}_t + \widehat{m}_t)$$

subject to

$$\tilde{c}_t + p_t \widetilde{m}_t + \hat{p}_t \widehat{m}_t = \tilde{e}$$

where the optimality condition depends on the comparison between the price of variegated Monstera and the outside option. If $p_t \geq \hat{p}_t$, consumers prefer variegated Monstera to the outside option and Equation (1) remains valid. However, if variegated Monstera becomes more expensive than the outside option at any point in time, consumers totally replace variegated Monstera with the outside option and move out of variegated Monstera market as summarized below;

$$p_t > \hat{p}_t > 0 \Longrightarrow \widetilde{m}_t = 0 \Longrightarrow \varphi\tilde{V} = 0 \tag{6}$$

If the price of variegated Monstera is too high, all consumers will leave the market and only investors remain. Therefore, the economy switches from the fundamental equilibrium system to the bubbly equilibrium system of Equation (4) and (6). This new bubbly equilibrium system is summarized in Lemma 2 and Proposition 2 below.

Lemma 2

For $\varphi\tilde{V} = 0$, the bubbly equilibrium system has two steady-state investor's variegated Monstera purchase values which are 0 and $V_b \in (0, e_1 - k)$.

Proof

Given $\varphi\tilde{V} = 0$, $p_t m_t = p_{t+1} m_{t+1} = 0$ trivially satisfies Equation (4). Moreover, the existence proof of V_f in Lemma 1 is still valid for the case of $\varphi\tilde{V} = 0$ and hence $V_b \in (0, e_1 - k)$ must also result in the bubbly equilibrium system. Q.E.D.

Proposition 2

For $\varphi\tilde{V} = 0$, the positive steady state V_b is purely bubbly.

Proof

From Equation (5), $p_{f,t} m_t = 0$ when $\varphi\tilde{V} = 0$. Trivially, $V_b > 0$ must purely contain bubbles.

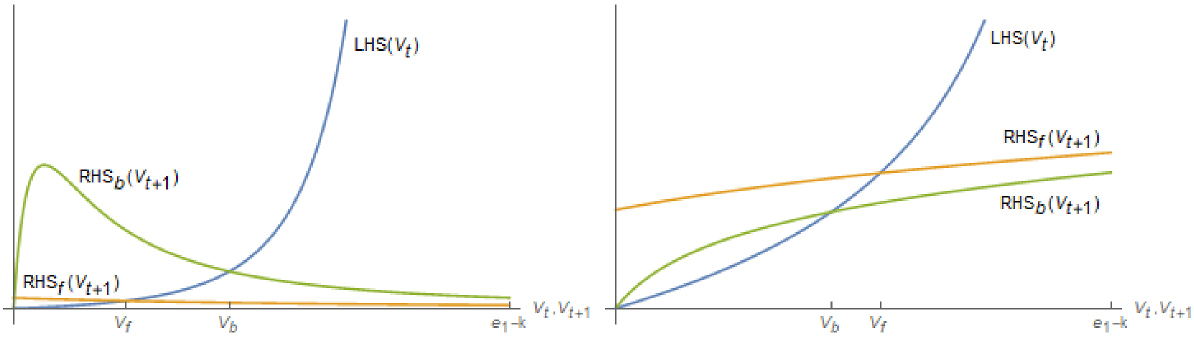
Note that the bubbly equilibrium system only emerges when $p_t > \hat{p}_t > 0$. If the economy is somehow disturbed which leads to the sufficient increase in variegated Monstera price, all consumers will move out of variegated Monstera market. The equilibrium system will change from the fundamental to the bubbly one where the variegated Monstera price is high (associated with the steady state V_b). However, the bubbly equilibrium system has the other steady state where the variegated Monstera price is zero. It is well known that multiple equilibria allow for a sudden switch of equilibrium depending on the coordination of beliefs. In this particular context, the sudden dropdown is a bubble bursting. However, the bubble does not burst on the zero steady state as the variegated Monstera price would have been below the price of the outside option and the economy switches back to the fundamental equilibrium system. Therefore, the variegated Monstera price will crash towards V_f instead. To sum up, we have a regime-switching equilibrium system with two relevant steady states: V_f in the fundamental regime and V_b in the bubbly regime.

In detail, there are many possibilities regarding this regime-switching idea. To simplify the discussion, let us assume $\hat{p}_t m_t = \hat{p}_{t+1} m_{t+1} = \hat{V} > 0$. For example, we may have the regime-switching equilibrium system where the pure coordination of beliefs leads to both boom and bust of bubbles. This requires the price dynamic in the bubbly regime to be higher than that of the outside option which implies $V_f \leq \hat{V} < V_b$. However, this is not as the case. Consider how V_b changes V_f according to the right-hand side of Equation (4) as follows;

$$\frac{dRHS}{d\varphi\tilde{V}} = \frac{\beta(1+n)\left[e_2 + (1+n-\theta)\left(V_{t+1} + \varphi\tilde{V}\right)\right]}{\left[e_2 + (1+n)\left(V_{t+1} + \varphi\tilde{V}\right)\right]^{1+\theta}}$$

which implies that $V_f < V_b$ only when θ is sufficiently high (at least $\theta > 1 + n$ in order to have $dRHS/d\varphi\tilde{V} < 0$). Note that θ^{-1} is an Elasticity of Intertemporal Substitution (EIS). Investors with high EIS are more willing to substitute the consumption when old with consumption when young. This lessens the importance of variegated Monstera as a store of value. In other words, variegated Monstera is not so necessary for them compared to those with low EIS.

Figure 1 Equilibrium dynamic diagram of variegated Monstera value



(a) low EIS (b) high EIS

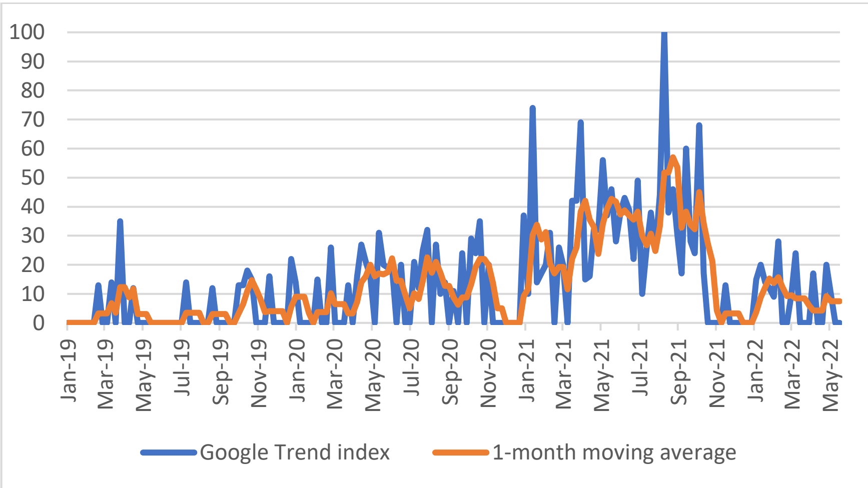
According to Chakravarty et al. (2016), people in Asia and Pacific region have relatively lower EIS compared to the rest of the world. Thereby, we would expect Asia and Pacific region to be a fertile ground for bubbles in prices of aesthetic goods. Figure 1 shows the dynamic graphs of Equation (4) under both fundamental and bubbly regimes for different values of EIS.[6]

However, if we allow the change in belief to have an extra exogenous influence to the economy, this will open more possibilities of having boom-bust episode of bubbles in spite of θ being low. The next section illustrates such the issue.

4 Conjecture on What Happened in the Variegated Monstera Market in Thailand

Around the middle of 2020, there was a hype over variegated foliage plants which variegated Monstera stood as the leader. More attentions were drawn towards variegated Monstera market and the price started to boom. The boom continued until the end of 2021. Figure 2 shows the Google Trend on the keyword "Monstera" searched in Thailand under the home-and-garden category which approximately represents the hype of variegated Monstera market in Thailand over time.

Figure 2 Thailand's variegated Monstera hype



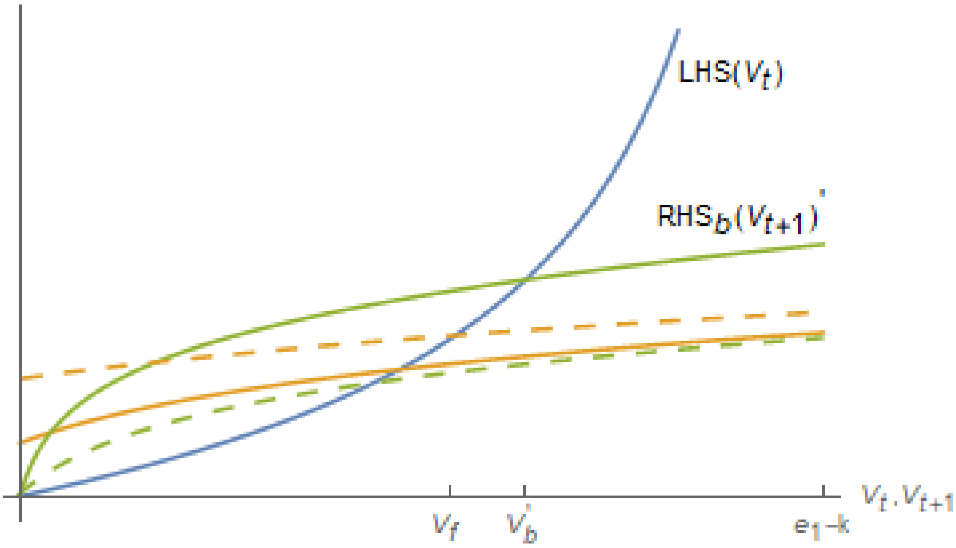
Based on our theoretical model analysed in the previous section, our conjecture of what happened to Thailand's variegated Monstera market is as follows. The drastic shock of COVID-19 hit Thai economy on March 2020 and disabled many economic activities. With the lockdown and social distancing policy, many people lost their jobs and investment opportunities in many markets were vaporized. We conject that people began to coordinate their beliefs on the potential of variegated Monstera market as variegated Monstera can be aesthetically enjoyed at home and its reproduction is neither too costly nor too complicated. Under such the belief, the large amount of new investors suddenly entered the variegated

[6] Alternatively, we may have $\hat{V} < min\{V_f, V_b\}$ where the economy has invalid V_f and bubbles stay persistent. Also, we may have $max\{V_f, V_b\} \leq \hat{V}$ which results in stable fundamental price. We may even have the case $V_b \leq \hat{V} < V_f$ where both of these steady states are invalid and the equilibrium dynamic keeps wandering around. These three cases do not permit the boom-bust episode of bubbles due to the regular coordination of beliefs.

Monstera market and demanded more variegated Monstera for reproduction purpose. This raised the price beyond the other aesthetic goods which pushed away all real variegated Monstera lovers and drove the equilibrium system into the bubbly regime. Over a year of magical variegated Monstera boom, people started to suspect the sustainability of the bubbly steady state. Such the pessimism caused the sudden stop. The variegated Monstera price crashed, the equilibrium system switched back to the fundamental regime, and the economy eventually reached the fundamental steady state again.

In other words, the number of investors here is a function of belief. The optimistic belief lures more investors to the market, the high price removes all consumers, and bubbles boom. This translates into an increase in n (from n to n') and a dynamic decrease in φ. This helps shift $RHS_b(V_{t+1})$ in Figure 1 upward while $RHS_f(V_{t+1})$ keeps moving down, so that V_b can be greater than V_f even in Figure 1(b) where EIS is high as shown in Figure 3.

Figure 3 Rise of Optimistic Investors



For this example in Figure 3, V_f and V_b' are both unstable steady states. Initially, the economy is at $V_f < \hat{V}$ where variegated Monstera has fundamental price. From Equation (3), the dynamic of m_t and p_t in the fundamental regime is determined as follows;

$$\begin{bmatrix} m_t \\ p_t \end{bmatrix} = \begin{bmatrix} \left(\frac{Ak^\alpha}{1+n}\right)\left(\frac{V_f}{V_f+\varphi\tilde{V}}\right) m_{t-1} \\ \frac{V_f}{m_t} \end{bmatrix} \tag{7}$$

where the fundamental price can be constant only if $1 + n = Ak^\alpha V_f / (V_f + \varphi\tilde{V})$.

The change in belief draws in more investors, pushes out all consumers, changes the right-hand side of the system from the dashed lines to the solid ones, and the equilibrium switches to $V_b' > \hat{V}$ where the price is pure bubbles. From Equation (3), the dynamic of m_t and p_t in the bubbly regime is determined as follows;

$$\begin{bmatrix} m_t \\ p_t \end{bmatrix} = \begin{bmatrix} \left(\frac{Ak^\alpha}{1+n'}\right) m_{t-1} \\ \frac{V_b'}{m_t} \end{bmatrix} \tag{8}$$

which the m_t is decreasing and the bubbly p_t is increasing only if $1 + n' > Ak^\alpha$. Once the bubbles burst, the economy goes back to the fundamental price at V_f.

Note that the typical boom-bust pattern of variegated Monstera price bubble between the regime-switching steady states can only take place when the belief-driven change in population growth of investors is significantly high. If not, the growth rate of bubbly price would be slower than the fundamental one. Denote $(\Delta p_{t+1}/p_t)_i$ where $i = f, b$ as the growth rate of price in fundamental and bubbly regimes respectively. Proposition 3 summarizes the result.[7]

Proposition 3

Regardless of EIS, $(\Delta p_{t+1}/p_t)_b > (\Delta p_{t+1}/p_t)_f$ if $n' > n + Ak^\alpha \varphi\tilde{V}/\left(V_f + \varphi\tilde{V}\right)$.

Proof

Trivial from Equation (7) and (8).

5 Empirical Evidence: Thailand's Variegated Monstera

Figure 4: Selected types of variegated Monstera

(a) Thai Constellation (b) Borsigiana Albo (c) Borsigiana Aurea

[7] In the long run, we think that the productivity A plays a role in adjusting the equilibrium price to eventually approach the constants in either fundamental or bubbly regimes. When the price is rising, there will be an attempt to improve A. When the price is falling, less care will be given so A deteriorates. The endogenous dynamic of A is however beyond the scope of this work.

(d) Adansonii Albo (e) Adaonsonii Aurea (f) Half-moon pattern

Source: Plants Harem and IG/FB: plantmeplanet

We collect the transaction data of variegated Monstera from the particular Facebook private group called "เสนอราคา ไม้ฟอกอากาศ Thailand". The group was created on May 6th, 2020 and now becomes the biggest variegated foliage plant group in Thailand in which over 343 thousand members involve in daily transactions. Similar to auctions, the member who wants to sell their plant creates a post containing its information and pictures which are visible to all members. Anyone who is interested in the plants can bid up a price in the comment. If the seller is satisfied, the plant is sold to the one with the best bid.

We only focus on five types of variegated Monstera as shown: Monstera Thai-Constellation, Monstera Borsigiana Albo Variegata, Monstera Borsigiana Aurea Variegata, Monstera Adansonii Albo Variegata, and Monstera Adansonii Aurea Variegata as shown in Figure 4(a)-4(e) respectively. In our sampling process, we use relevant key words to search for the posts within the group. Only the post with a complete transaction is selected. The detailed characteristics of sold variegated Monstera are then recorded together with other important information of the post like the selling price, size of the pot, the number of likes, and the number of bids. Moreover, we use the Google Trend index representing the relative frequency that people in Thailand Google search the word "Monstera" for each day. To sum up, our pooled-data sample consists of 510 transactions taking place over July 13th, 2020 to June 12th, 2022. The regression specification is given below;

$$\ln Price_i = a_1 + a_2 BorsAlbo_i + a_3 BorsAurea_i + a_4 AdanAlbo_i$$
$$+ a_5 AdanAurea_i + a_6 Leaves_i + a_7 Matured_i + a_8 PotSize_i$$
$$+ a_9 Likes_i + a_{10} Bids_i + a_{11} GtrendLag_i + a_{12} T_i + a_{13} T_i^2 + \varepsilon_i$$

where the winning price ($Price_i$) is used as the dependent variable in the regression. We include the three categories of the explanatory variables. First, the dummy variables for the species of variegated Monstera are used where $BorsAlbo_i$ is a dummy for Monstera Borsigiana Albo Variegata, $BorsAurea_i$ is a dummy for Monstera Borsigiana Aurea Variegata, $AdanAlbo_i$ is a dummy for Monstera Adansonii Albo Variegata, $AdanAurea_i$ is a dummy for Monstera Adonsonii Aurea Variegata. The benchmark group is Monstera Thai Constellation. Second group of variables characterize for the size of plant, which could be proxy by: the number of leaves ($Leaves_i$), existence of matured leaves, which is present by a dummy for having matured leaves ($Matured_i$). $PotSize_i$ is the size of the pot which is a proxy of the size of plants in the pot. Next, we include $GtrendLag_i$, which is the one-week-lagged Google Trend index of the word "Monstera" searching in Thailand during 2020-2022 (calculated on September 30th, 2021), $Likes_i$ is the number of Facebook likes, $Bids_i$ is the number of bids. These variables are applied as the proxy for attention of public to the variegated Monstera. Finally, we use a time trend variable, T_i , when July 13th, 2020 is the initial date.

Our modelling strategy is to separate the fundamental component by controlling factors determining the fundamental price. For aesthetic characteristics, we control the species, the type of variegation of each Monstera, number of leaves, and the maturity of leaves. For the reproduction process, although we do not have the direct cost data, we use the size of pots, number of leaves, and the maturity of leaves as proxies. For the income, we do not have the income data of buyers. However, the price boom occurs during 2020-2021 which is a hard time under the COVID-19. Therefore, it is reasonable to assume that the overall income of buyers is constant for the whole duration of our sample. Lastly, we use the number of Facebook likes, number of bids, and Google Trend index to capture the market growth.

By controlling all fundamental factors, what is left is the bubble component. According to our conjecture in the previous chapter, we expect the quadratic time trend to capture the existence of the variegated Monstera bubble and its boom-bust episode.

The result in Table 1 is consistent with our theory and conjecture. Almost all variables are statistically significant with the expected signs. Out of five types of variegated Monstera, the benchmark Thai-constellation Monstera has to lowest fundamental price. The matured variegated Monstera with more leaves, bigger pot is more fundamentally expensive. The greater number of Facebook likes, bids, and Google Trend index makes variegated Monstera rarer which raises the fundamental price level. Most importantly, the quadratic time trend of logarithm of variegated Monstera is statistically significant with the negative sign. This serves as an evidence of a boom-bust episode of variegated Monstera bubbles. For example, Figure 5 plots the time path of average price of Thai-constellation Monstera estimated from the regression in Table 1.

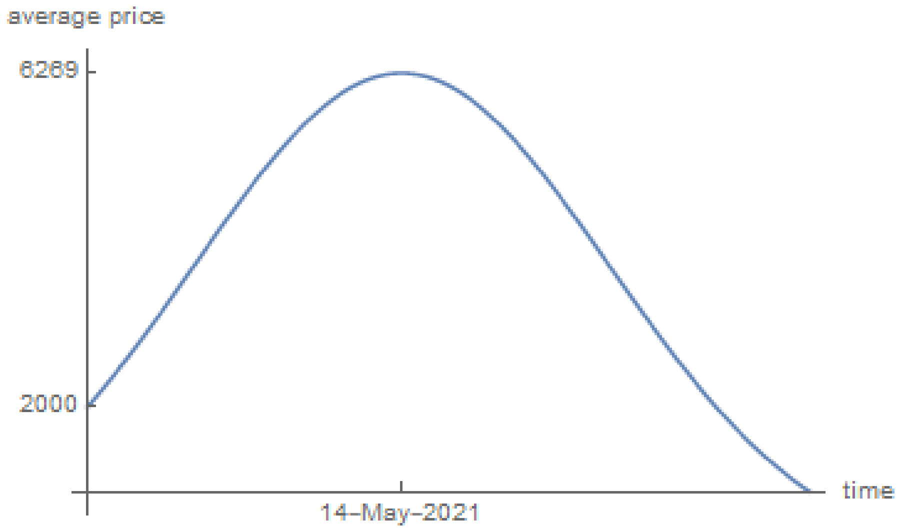
Table 1 Regression Results

Dependent variable: ln $Price_i$			
Method: OLS / White heteroscedasticity-consistent standard error & covariance			
Variable	Coefficient	Variable	Coefficient
$Constant$	6.4981***	$PotSize$	0.0688***
$BorsAlbo$	0.6999***	$Likes$	0.0005***
$BorsAurea$	1.4451***	$Bids$	0.0172***
$AdanAlbo$	1.6656***	$GtrendLag$	0.0025**
$AdanAurea$	1.1618***	T	0.0075***
$Leaves$	0.1317***	T^2	-1.23×10^{-5}***
$Matured$	0.2947***	No. Obs	510

, are respectively referred to being 5%, and 1% statistically significant.*

In addition, if we keep shortening the sample period to focus more on the early development of the price boom, Table 3 shows that the estimated coefficients of the reciprocal of time become less negative (from -1.5162 to -0.8496) as the earlier the sample period is selected. In other words, the bubble component shows the steeper trend at the beginning of the price boom. The trend becomes less steep over the extended durations, while the S-shaped dynamic always remains. All these results support our theory well.

Figure 5 In-sample estimated average price of Thai-constellation Monstera over time



Can the theory help explain Tulip Mania? Yes, it can. Tulips are clearly an aesthetic asset and Tulip Mania is indeed a bubble event. Thompson (2007) documents that the huge hike in the tulip price index happened during November to December 1636 when considerable number of people all over Europe were drawn into the tulip market, and then it slowed down till it reached the peck at February 3rd, 1637. It is known that the sharp fall took place during that February but the data from February 9th till April 30th were completely missing which means that we are not certain about the duration of the tulip's price crash. Such the rising tulip price development followed by the crash resembles the bubbly dynamic of variegated Monstera price in Figure 5.

6 Conclusion

We construct the rational bubble theory for newly-defined aesthetic good. Such the good tend to be overlooked by the literature as it only gives the aesthetic pleasure and pays no dividend.

According to our theoretical model, rational bubbles cannot exist if there are still consumers who truly aesthetically enjoy these goods. However, the coordination of beliefs can draw new investors into the market, drive up the price, and push away those consumers. Without them, rational bubbles can exist. Once the optimism ends, the bubble bursts and the equilibrium falls back to the fundamental one.

This evidently explains the boom-bust episode in the Thailand's variegated Monstera market during 2020-2021 and serves a potential explanation underlying the fall of Tulip Mania.

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Appendix

The proof of no bubble in an n-period cycle equilibrium given $\varphi\tilde{V} > 0$

Suppose there exists an n-period cycle satisfying Equation (3) where $V_{t-1+ni+j} = V_j$ for $i = 0,1,2,...$ and $j = 1,2,3..,n$. Notably, $d_{t-1+ni+j} = d_j = \frac{V_j}{V_{j+1}+\varphi\tilde{V}}$ where $V_{n+1} = V_1$. Therefore, $\prod_{j=1}^{n} d_j = \prod_{j=1}^{n}\left(\frac{V_j}{V_j+\varphi\tilde{V}}\right) \in (0,1)$ From Equation (4), we can rewrite the fundamental value as follows;

$$p_{f,t}m_t = \varphi\tilde{V}\left(\sum_{i=1}^{n}\prod_{j=1}^{i} d_j\right)\left[\sum_{i=0}^{\infty}\left(\prod_{j=1}^{n} d_j\right)^i\right]$$

$$= \varphi\tilde{V}\left[\frac{V_1\prod_{j\neq 2}(V_j+\varphi\tilde{V})+V_1V_2\prod_{j\neq 2,3}(V_j+\varphi\tilde{V})+\cdots+\prod_{j=1}^{n}V_j}{\prod_{j=1}^{n}(V_j+\varphi\tilde{V})}\right]\left[1-\prod_{j=1}^{n}\left(\frac{V_j}{V_j+\varphi\tilde{V}}\right)\right]^{-1}$$

$$= \frac{\varphi\tilde{V}V_1\left[\prod_{j\neq 2}(V_j+\varphi\tilde{V})+V_2\prod_{j\neq 2,3}(V_j+\varphi\tilde{V})+\cdots+\prod_{j\neq 1}V_j\right]}{\prod_{j=1}^{n}(V_j+\varphi\tilde{V})-\prod_{j=1}^{n}V_j} = V_1 = p_t m_t \Longrightarrow p_{b,t}m_t = 0$$

where by carefully expanding the term it results that $\prod_{j=1}^{n}\left(V_j+\varphi\tilde{V}\right)-\prod_{j=1}^{n}V_j$ coincides with $\varphi\tilde{V}V_1\left[\prod_{j\neq 2}\left(V_j+\varphi\tilde{V}\right)+V_2\prod_{j\neq 2,3}\left(V_j+\varphi\tilde{V}\right)+\cdots+\prod_{j\neq 1}V_j\right]$. Q.E.D.