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## On failure of zoning

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### Shih-Kung Lai

College of Public Administration,  
Zhejiang University, Hangzhou, China,  
and  
Department of Real Estate and Built Environment,  
National Taipei University,  
67, Section 3, Min Sheng East Road, Taipei, Taiwan  
Fax: +886-2-2507-4266  
E-mail: lai@mail.ntpu.edu.tw

### Haoying Han\*

Department of Land Management, Zhejiang University,  
268 Kaixuan Road, Hangzhou 310029, China  
E-mail: hanhaoying@zju.edu.cn  
\*Corresponding author

**Abstract:** Zoning is designed to delineate land uses in order to prevent urban development from incurring negative externalities. Morphologically speaking, zoning should result in spatial patterns that are closer to Euclidean (or regular) geometry than fractal (or irregular, self-similar) geometry. Previous computer simulations showed that zoning did not affect the fractal geometry of the urban spatial patterns of the Taipei metropolitan area. In this paper, we explore into the reasons why zoning fails in most Asian cities in general, and in Taipei in particular, through theoretical expositions. We argue that the preference for mixed uses is the main reason why zoning fails to achieve its goals. Furthermore, even a limited extent of mixed uses would result in spatial patterns characterised by fractal geometry rather than Euclidean geometry. We argue for a hybrid land regulation through the zoning and permit systems that take advantage of both the artificial and natural aspects of cities.

**Keywords:** zoning; fractal; urban development.

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**Biographical notes:** Shih-Kung Lai is a Professor of College of Public Administration at Zhejiang University, China and Department of Real Estate and Built Environment at National Taipei University, Taiwan, where he conducts research on urban complexity and planning. He received his PhD in Regional Planning from the Department of Urban and Regional Planning at University of Illinois at Urbana Champaign. His teaching areas include urban planning, planning analysis, economic analysis of planning behaviour, and urban and regional spatial change.

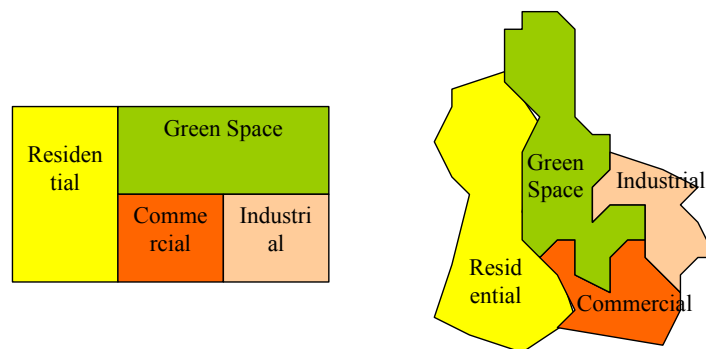
Haoying Han received his BArch and MS in Tsinghua University P.R. China, and his PhD in the University of Tokyo, Japan. He is now an Associate Professor in Zhejiang University P.R. China. He has focused his research on urban and regional development, planning analysis and city management.

## 1 Introduction

Zoning is a device of land use regulation used by local governments in most developed countries to control urban development.<sup>1</sup> Zoning may be use-based (regulating the uses to which land may be put), or it may regulate building height, lot coverage, and similar characteristics, or some combination of these.<sup>2</sup> Theoretically, the primary purpose of zoning is to segregate uses that are thought to be incompatible and then to prevent urban development from incurring negative externalities.

Zoning typically segregates land uses into three main categories – residential, commercial, and industrial. Thus, if a section of a city is zoned as residential, then no commercial uses are allowed in that area so a grocery store cannot be built within a housing area. In practice, zoning is also used to prevent new development from interfering with existing residents or businesses and to preserve the ‘character’ of a community. Morphologically speaking, zoning should result in spatial patterns that are closer to Euclidean geometry than fractal geometry. We define here the former as a segregation of land uses into specified, regular geographic districts; while the latter as jagged interfaces of different land uses, which are irregular but self-similar at different spatial scales (see Figure 1).

**Figure 1** Conceptual image of Euclidean geometry (left) and that of fractal geometry (right) (see online version for colours)



While zoning has served to protect property values and has enhanced the use of the automobile, it has created less than appealing cities. Traditional zoning has been proven as less than popular in many cities and then changed gradually<sup>3</sup>. We argue that the design of land use regulation system should adopt, to some extent, market mechanism. Otherwise, government intervention is less effective. There are many variants of zoning between these two extremes of single- and mixed-use, such as floating zoning, overlaying zones, incentive zoning, contract zoning, conditional rezoning, cluster zoning,

performance zoning, transfer of development rights, special zoning, and planning permission. However, they differ with each other in execution rather than in principle.

Lai and Chen (2006) assessed the probability of development based on economic property right indices and the probability of possible land use allowed in the zoning system and showed that zoning did not affect the fractal geometry of the urban spatial patterns of the Taipei metropolitan area. In this paper, we pursue further why zoning fails in most Asian cities in general, and in Taipei in particular, by exploring into the reasons through theoretical expositions.

We first provide theoretical explanations of how zoning should work in that zoning presumably delineates completely property rights to land uses, through which land prices are fully reflected in the land market. Developers then follow the price mechanism set in the land market to transact and develop land, resulting in desired, zoned spatial patterns.

We hypothesise that in some cities, such as Taipei, this logical sequence does not exist. More specifically, the zoning system in Taipei might not delineate property rights to land sufficiently effective so that land prices in the land market might be distorted by the system and they would not reflect the associated property rights in an appropriate way. The mixed-uses spatial pattern under the zoning system as manifested by the Taipei case might result from the failure of such a logical sequence.

The rest of the paper is structured as follows. In the second section, we review some commonly used zoning systems worldwide and then, in the third section, provide some theoretical explanations for why zoning fails in most Asian cities. In the fourth section, we discuss possible improvement strategies for the current zoning practice in these cities. We offer some conclusions in the final section of the paper.

## **2 International practices of zoning systems**

The initiative of zoning is to separate one set of land uses from another. However, the implementations of land uses separation are diverse across cultures and regions. In North America, strict segregation of different uses is predominant. This has been criticised by many planners and critics of current development practices in that it prevents the creation of liveable and aesthetically pleasing communities (Jacobs, 1961). More recently, many cities have adopted mixed-use zones that allow some, but not all, of the different uses to be built near one another in order to reduce transportation times between homes and workplaces, and to decrease the monotony of uniform areas of land uses. Some cities adopt zoning that allows certain land uses automatically, but requires other uses to go through a careful review, and prevents other uses altogether (Elliott, 1993). Many states in the USA allow their cities and counties to develop more flexible types of zoning or types that can achieve multiple objectives. The innovations of zoning include incentive zoning, inclusionary zoning, performance system, form-based codes, etc. (Porter, 1988; Lassar, 1989; Williams, 1992; Lynch, 2003; Katz, 2003). In these new types of zoning, requirements of land use segregation become looser than the traditional Euclidean zoning. In other cultural backgrounds, zoning with even more mixed uses have been adopted. For example, in Japan, the land use zoning categories evolve from the pure segregation of three zones (residential, commercial and industrial) in 1919 to a 12 land uses in 1992. The residential zones allow almost any use, although with a lower permitted floor area ratio (FAR) and plot coverage than in commercial (Sorenson, 2002). Even in many industrial districts, housing is also allowed (see Table 1).

**Table 1** Evolution of Japanese land use zoning categories and mixed-use related requirements

	1919	1950	1968	1992	Mixed-use related requirement
Residential	Residential	Category 1 Exclusive residential	Category 1 Exclusive residential	Category 1 Exclusive low-story residential	Small store of offices up to 50 m <sup>2</sup> permitted
		Category 2 Exclusive residential	Category 2 Exclusive residential	Category 2 Exclusive low-story residential	Certain types of stores and offices up to 150 m <sup>2</sup> permitted
				Category 1 Exclusive medium-high residential	Certain types of stores and offices up to 500 m <sup>2</sup> permitted
				Category 2 Exclusive medium-high residential	Certain types of stores and offices up to 1,500 m <sup>2</sup> permitted
		Residential		Category 1 Residential	Certain types of stores and offices up to 3,000 m <sup>2</sup> permitted
				Category 2 Residential	
				Quasi-residential	
Commercial	Commercial	Commercial	Commercial	Commercial	Theatres and dancing halls are prohibited
Industrial	Industrial	Industrial	Industrial	Neighbourhood commercial	
	Quasi-industrial	Quasi-industrial	Quasi-industrial	Industrial	
				Quasi-industrial	On the premise of intermingling with housing, small-scale factories that do not cause serious hazards are permitted
				Exclusively industrial	Housing is prohibited

Source: Japan Ministry of Construction, City Bureau (1996)

**Table 2** Advantages and disadvantages of different types of zoning

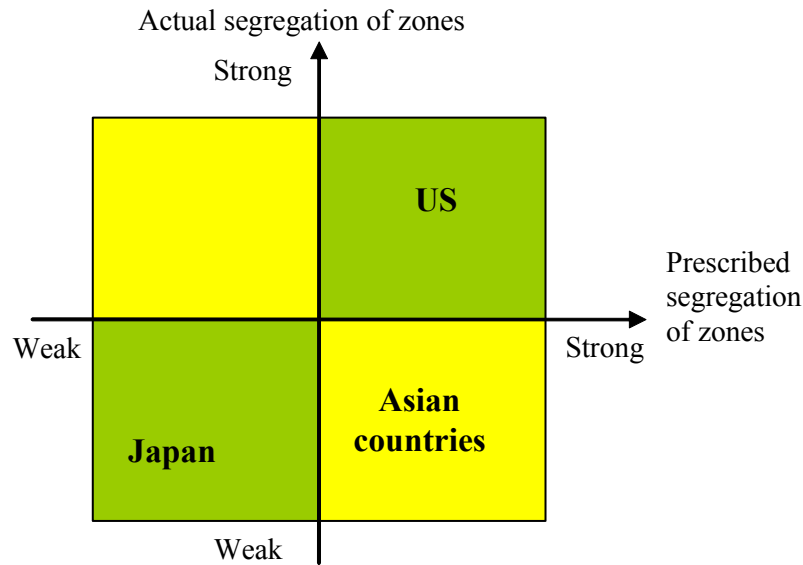
<i>Item</i>	<i>Euclidean zoning</i>	<i>Incentive zoning Inclusionary zoning</i>	<i>Performance zoning Form-based codes</i>	<i>Mixed-uses zoning</i>
Intensity of mixed use	Very weak	Weak	Strong	Very strong
Major areas of application	USA	USA	USA	Japan
Advantages	<ul style="list-style-type: none"> <li>• Little disturbance of different land uses</li> <li>• Low transaction costs</li> <li>• Ease of approval and implementation</li> <li>• Long-established legal precedent</li> <li>• Transparent information flow</li> </ul>	<ul style="list-style-type: none"> <li>• Flexible</li> <li>• Able to achieve multiple development objectives</li> </ul>	<ul style="list-style-type: none"> <li>• Flexible</li> </ul>	<ul style="list-style-type: none"> <li>• Easy household-workplace commuting</li> <li>• Compact and Efficient overall land use pattern</li> </ul>
Disadvantages	<ul style="list-style-type: none"> <li>• Lack of flexibility</li> <li>• Inefficient land use primarily characterized by difficult household-workplace commuting</li> </ul>	<ul style="list-style-type: none"> <li>• Complex to administration</li> <li>• Time consuming</li> <li>• Dangers of corruption</li> </ul>	<ul style="list-style-type: none"> <li>• Complex to administer</li> <li>• Time consuming</li> <li>• Dangers of corruption</li> <li>• Difficult to supervise and monitor</li> </ul>	<ul style="list-style-type: none"> <li>• Disturbance of different land uses</li> <li>• High supervision and monitoring cost</li> </ul>

Of different types of zoning practices, advantages and disadvantages can be summarised and compared as shown in Table 2.

The advantages of Euclidean zoning<sup>4</sup> include little disturbance of different land uses, low transaction costs, ease of implementation, long-established legal precedent and transparent information flow. However, Euclidean zoning has received criticism for its lack of flexibility, inefficient land use primarily characterised by difficult household-workplace commuting and institutionalisation of now-outdated planning theory. On the contrary, the Japanese style of mixed-use zoning allows flexible spatial pattern, easy household-workplace commuting and compact and efficient overall land use pattern; while it inevitably suffers, though not seriously, from the disturbance of different land uses and relatively high supervision and monitoring cost. The other types of zoning, such as incentive zoning, inclusionary zoning, performance system and form-based codes, have more or less, the advantages and disadvantages of the two extremes. Thus, these zoning types can be shown in a clear gradient according to their intensity of mixed use as depicted in Table 2.

The extents of mixed use to which zoning realises are diverse in practice primarily because there are different expectations and valuations of what our cities should be across cultures and regions. The advantages of strict zoning are exactly what are lacking in mixed-use zoning and vice versa. Those advantages and disadvantages are valued differently in regions with different cultures, resources and economies. For instance, USA usually put more weight on easy application and approval in land development and few disturbances of different land uses in order to facilitate the real estate transaction; while they do not weigh too much on the lack of flexibility and inefficient land uses probably because these weaknesses can be alleviated by its rich land resources. However, the Japanese tend to prefer mixed-use areas with better life convenience. The Japanese cultural preference for high density and mixed land use and the fact of relatively scarce land resources in Japan are probably the most important reasons. Those international examples of the extent of mixed use to which zoning realises show that whether a specific type of zoning system would be adopted in a region or country may depend on the overall evaluation of both the advantages and disadvantages based on the culture and environmental settings of that region or country. However, in some countries, the establishment of the zoning system is not a carefully planned process, but a lash-up. For example, many of Asian countries inherited the zoning system from USA and Europe. The success or failure of its adopted zoning system depends on whether it accords with the cultural preference and natural environment of that country. In most of those Asian countries, the actual implementation of zoning is much weaker than the institutional prescription of it. As a result, mixed uses are usually prevalent in the prescribed exclusive zoning areas, rendering the land use control of zoning as a failure in practice. Figure 2 shows the performance of zoning in different countries by prescribed vs. actual segregation of zones. We define the success of a zoning system as one that results in a spatial pattern conforming to its map (Hopkins, 2010). In other words, a zoning system is successful only when the prescribed and actual segregations of zones are consistent. According to this narrow standard of conformance, the zoning systems in the USA and Japan are considered successes, whereas those in most, if not all, other Asian countries failures.

**Figure 2** Failure areas of zoning based on the prescriptions and actual implementations of the segregation in zoning (gray background indicates the failure area of zoning; dark background indicates the well implemented area of zoning) (see online version for colours)



### 3 Possible explanations based on behavioural economics

The original purpose of zoning is to confine different land uses in respective delineated zones in order to eliminate external diseconomies, including noise, traffic congestion, and air pollution. However, zoning has an unexpected, important impact on land development decisions, in particular decreasing developers' cost of planning through reducing uncertainties or risks (Lai, 2002). What is less known, however, is that land policies to reduce risks of development decisions, such as zoning, would encourage developers to seek suboptimal development by moving quickly from one project to another, thus reinforce urban sprawl rather than confining it (Mohamed, 2006). Despite the lack of consensus on a specific definition of sprawl (Downs, 1999; Ewing et al., 2002; Beck et al., 2003; American Farmland Trust, 1997), we define sprawl as dispersed, low-density, and auto-dependent development.

If follows that zoning that allows to a limited extent mixed uses would not only reinforce urban sprawl but also enhance the mixed uses pattern of urban spatial patterns because development projects would be fragmented over space and time, resulting in fractal rather than Euclidean structure of urban morphology as demonstrated by Lai and Chen's simulation(2006). The following provides a theoretical account of this argument.

Drawing on prospect theory, Mohamed (2006) proposes structural explanations of why developers seek suboptimal development decisions, that is satisfying, not from the perspective of bounded rationality, but from one of behavioural economics. In particular,

he argues for four major psychological influences on developer decision making: myopic bracketing, mental accounting, liquidity constraining, and temporal spacing, all four influences being derived from the s-shaped value function of prospect theory. Myopic bracketing implies that developers narrowly bracket their decisions one project at a time due to the fact that the most important reference point on the s-shaped value function is the profit target for each project. Mental accounting divides developer investment into primary and secondary investments and primary investments allow developers to achieve their profit targets. Because of this distinction, developers only reluctantly make secondary investments. Liquidity constraining is a direct consequence of mental accounting; because investment money is non-fungible, developers establish self-imposed liquidity constraints and developers are unwilling to make secondary investments. Temporal spacing occurs because segregating gains from different projects carries a higher cumulative value than if all the gains were to come at the same point in time from a single project. All these psychological influences explain why developers prefer to move from one project to another and invest in greenfield sites. In particular, when the approval process is more predictable this tendency becomes more salient. Mohamed (2006) continues to argue that "do local governments unwittingly promote sprawl when they introduce policies to make the development process more predictable?" The answer appears to be tentatively yes, due to the reasons depicted.

Now back to the zoning issue. Zoning no doubt makes the development process more predictable, and therefore, according to Mohamed's argument, it would unwittingly promote sprawl. The question remains of how this would happen. We argue that zoning reduces risks and uncertainties associated with development decisions, and thus decreases developers' planning cost so that developers have more development money to make primary investment<sup>5</sup> which would increase the sequence of development projects under consideration. As a result, due to the fact that the greenfield sites in suburban areas are preferred in making these primary investments, developers continue to move quickly from one project to another in locations in these areas, causing increased urban sprawl.

As for the issue of mixed uses, we argue that as long as the zoning system allows to a limited extent mixed uses, as the cases of Taiwan and Japan, the system would result in fractal rather than Euclidean structural morphology. First, according to Schelling (2006), segregation of neighbourhoods emerges when there is mild prejudice against different ethnic groups. On the other hand, we argue that if there is no discrimination against mixed uses, which would be the case in most Asian cities, segregation in land use, would not occur. Second, mixed uses are a more natural development pattern that might yield higher target profits than single use because of increasing returns to complementarity of uses. Compare mixed uses and single use patterns of commercial and residential developments. In the mixed uses pattern, the adjacency between commercial and residential uses would result in higher property right capture that is left in the public domain as manifested by potential gains due to better accessibility between the two uses than when they are segregated, thus resulting in the total profits of the mutual development, which could be formulated as a prisoner's dilemma game as shown below.

Consider only two land uses, commercial and residential, which could be adopted by two developers on two neighbouring parcels in a community. The development decisions adopted by the two developers can be represented as a two-person, iterated prisoner's dilemma game in that each developer can either cooperate to develop the land for residential use or defect for commercial use. Nowak and May (1993) design a simplified version of the two-person, iterated prisoner's dilemma game that serves as a basis for our



deductive comparison. In their formulation, Nowak and May (1993) reduce the payoff table of the two-person, iterated prisoner's dilemma game into one that contains only one parameter as follows.

	<i>C</i>	<i>D</i>
<i>C</i>	1	0
<i>D</i>	<i>b</i>	0

In the above payoff table, the values represent the payoffs received by each player when that player (as shown in the rows) takes a certain action, while the other player (as shown in the columns) takes another action. For example, if player one cooperates and player two also cooperates, then player one will receive a payoff of unity. If player one defects while player two cooperates, then player one will receive a payoff of *b*. For the simplified version of the two-person, iterated prisoner's dilemma game to be equivalent to the original one, *b* must be greater than unity, so that the Nash equilibrium settles on the combination of actions where both players would defect.

Chiu and Lai (2008) compare four strategies in the simplified version of two-person, iterated prisoner's dilemma game, namely, always defect/cooperate (AD or AC), tit for tat (TFT), and random actions (RA). Always defect means to cooperate in the initial iteration, and once the other player defects in the current iteration, always defect in the subsequent iterations. Always cooperate means to cooperate in all encounters, regardless of what actions the other player takes. TFT means to cooperate in the initial iteration, and then respond by following the other player's action in the previous iteration. RA simply mean to take any action arbitrarily in each iteration with a certain probability distribution. Intuitively, in the land development context, AD or AC would result in single use and TFT and RA would result in mixed uses of spatial pattern. Chiu and Lai (2008) are able to show that in the case of an either limited or unlimited number of iterations, the ranking of strategies in terms of the overall expected payoff obtained by a single player is TFT, RA, AC, and AD, implying that the strategies resulting in the outcome of mixed uses are dominant. Note, however, that the TFT strategy might be difficult to adopt in practice because of the significant cost of revising a development decision, or irreversibility (Hopkins, 2001). Indeed, Hopkins (1979) argues that quadratic models reminiscent of mixed uses in plan making is more effective than linear-programming models reminiscent of single-used zoning. Both empirical and simulated data demonstrate that the spatial pattern of land uses in Taipei is fractal and mixed uses, rather than Euclidean and single use (Lin and Lai, 1998; Lai and Chen, 2006).

#### 4 Discussion and policy implications

Though land regulation can exclude incompatible land uses, provide public goods needed, disclose market information, and reduce transaction cost of land development, it also generates windfalls and wipe-outs, and induces rent seeking activities, which may turn zoning into a zero or even negative sum game.

From the theoretical analysis depicted, we argue that the preference for mixed uses in land in most Asian countries is the main reason why zoning fails to achieve its original goals. Furthermore, even a limited extent of mixed uses will result in a spatial pattern of

fractal geometry rather than Euclidean geometry. From the simulation results of Lai and Chen (2006), they also showed that zoning did not affect the fractal geometry of the urban structure of the Taipei metropolitan area. Does it imply that we should turn the current zoning system that allows mixed uses back to the traditional zoning?

As addressed in the previous section, mixed uses are a more natural development pattern. However, high intensities combined with mixed uses resulting from natural development would reduce the amenity or quality of residential environment, such as congested traffic and noise. On the other hand, mixed uses can increase the flexibility of land allocation, and the accessibility to commercial facilities for residents. So a mixed-use structure might yield higher target profits than a single-use pattern.

Since the traditional zoning has spatial and economic pitfalls and violates the characteristics of naturally developed cities, there are many improved zoning system arising during the last few decades. Is it possible to keep the spirit of zoning while maintaining mixed uses of natural development at the same time? In our view, no single variant of zoning system can achieve this goal, and we suggest a hybrid of traditional zoning and permit systems. It allows cities to zone a new section of development with mixed uses through a permit system to allocate offices and grocery stores near residential areas so people can work and shop at locations close to home. If we can arrange well the locations of different zoned areas, and the residents can choose accordingly their most favourite living environment based on their preferences, we could enjoy the benefits of mixed uses and still keep the urban spatial patterns more in line with Euclidean geometry than fractal geometry in the hope to achieve a smaller fractal dimension of spatial pattern that would be otherwise too high in naturally developed cities. Regardless, the zoning system should provide sufficient information about and delineate effectively rights in land in order for land development decisions to be made effectively and efficiently (Lai, 2001).

## **5 Conclusions**

Zoning is designed to delineate land uses in order to prevent urban development from incurring negative externalities. Morphologically speaking, zoning should result in spatial patterns that are closer to Euclidean geometry than fractal geometry. From the theoretical analysis, we argue that the preference for mixed uses is the main reason why zoning fails to achieve its goals in most Asian cities. Furthermore, even a limited extent of mixed uses would result in spatial patterns of fractal geometry rather than Euclidean geometry. We argue for a hybrid system of land regulation through both the zoning and permit systems that would result in a spatial pattern taking into account the advantages of both the artificial and natural cities. Both the explanations on failure of zoning and the proposed hybrid land regulation system beg further exploration.

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## Notes

- 1 Zoning is commonly controlled by local governments such as counties or municipalities, though the nature of the zoning regime may be determined or limited by state or national planning authorities or through enabling legislation. In Australia, land under the control of the Commonwealth (federal) government is not subject to state planning controls. The USA and other federal countries are similar. Zoning and urban planning in France and Germany are regulated by national or federal codes. In the case of Germany this code includes contents of zoning plans as well as the legal procedure.
- 2 In Germany, zoning usually includes building design, very specific green space and compensation regulations. The details of how individual planning systems incorporate zoning into their regulatory regimes vary though the intentions are always similar.
- 3 The city of Houston, Texas is notable for its lack of zoning ordinances, yet some are pushing for zoning in this final holdout city.
- 4 Euclidean zoning here refers to the zoning system that is most prevalent in the USA, named for the type of zoning code adopted in the town of Euclid, Ohio, and approved in a landmark decision of the US Supreme Court. It has nothing to do with Euclidean geometry as will be depicted shortly.
- 5 Mohamed (2006) posits that developers construct two non-fungible mental accounts: primary and secondary investments. Primary investments allow developers to achieve their profit targets. Secondary investments do not contribute to reaching profit targets but are profit opportunities that exist after the target has been met.