ANNALS OF ECONOMICS AND FINANCE **27-1**, 223–242 (2026)

A Dynamic Model of Chinese Economic Gradualism via Marketisation*

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This paper analyzes China's economic marketization since 1978. We provide a historical account showing its success resulted from gradualism and a trial-and-error process. We then develop a two-sector Ramsey model where an "experimental sector" with an unknown decentralized production process represents reforms. A central planner learns from this sector's revealed productivity, explaining China's smooth transition from a planned to a market-oriented economy through an information-learning process.

Key Words: Bayesian Learning; Policy experimentation; Chinese "take-off"; Marketisation.
JEL Classification Numbers: C62, D8, E32, O41.

1. INTRODUCTION

Government bears a significant responsibility in selecting the suitable policies to adopt and implement them using the most effective approaches. However, the process of acquiring knowledge and skills related to policy development can be difficult. The effectiveness of a policy typically depends

* We thank the Editor, an anonymous referee, and Tao Zha for helpful comments and suggestions. We would like to thank Cécile Bastidon, Steven Durlauf, Laurent Gauthier, Maxime Menuet and Vincent Touzé and participants to conferences at "Understanding Revolutions, War and Peace : A View From Cliometrics and Complexity Second edition", University of Chicago, Center in Paris, France, February 2023, at "Understanding Revolutions, War and Peace : A View From Cliometrics and Complexity, first edition", University of Chicago, Center in Paris, France, June 2022 and at "Conference on Complex System (Satellite Workshop CAC "Cliometrics and Complexity"), Lyon, France, October 2021. Of course any errors are our own.

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1529-7373/2026

on various factors such as the policy itself, its execution, how well it aligns with specific local factors, and the motivation of local politicians and local lobbies to ensure its success.

Numerous governments have resorted to policy experimentation, whether implicitly or explicitly, to address policy ambiguity and promote policy education. Policy experimentation can range from simple trial and error to rigorous randomised control trials conducted in specific regions of a country. However, none have matched the comprehensive and sustained policy experimentation conducted in China in terms of its scope, intensity, and duration. Since the end of 1970s, the Chinese government has methodically tested diverse policies across different regions, often iterating the experiments several times before deciding whether to implement the policies nationwide.[1]

The objective of this paper is to consider a specific experiment conducted in China — the marketisation of its economy since 1978 — and provide a historical account of it, as well as comprehend its principal mechanism via a simple dynamic economic model. Despite many scholars contending that the pursuit of marketisation was a crucial element that contributed to China's economic growth in the past forty years (Rawski 1995), there remains a significant lack of understanding regarding the features of marketisation.[2]

We consider a two-sector infinite horizon economy. In a first sector, called "centralised sector", the representative firm produces consumption goods according to the rule stated by the central planner, i.e. at a fixed price and for limited quantities. In a second sector, called "experimental sector", the representative firm produces consumption goods both according to the rule stated by the central planner (centralised production process) and by the market (decentralised production process). In such a sector, the representative firm does not know how is the quality of the production, the TFP of the technology is initially unknown, and experiments to know whether marketisation is possible. Indeed, a good production process in the market achieves a high TFP, and thus high production level, while a bad production process always achieves a low TFP, and thus a low production level. The representative firm in the "experimental sector" updates beliefs on the quality of the technology only after it is selected and productions are realised.[3] Households at each period of time consume each type of consumption goods and supply elastically labour in the "experimental sector".

[1]See Wang and Yang (2021) that analyse policy experimentation conducted in China over the past four decades by using comprehensive data.

[2]Fu et al. (2022) analyse the Chinese "take-off" in an evolutionary model without uncertainty where marketisation is not considered.

[3]This is considered as an "armed bandit" problem as in DeGroot (2004).

Due to production process selection, the true quality of the decentralised production process could still remain unlearned on the equilibrium path, which makes a significant difference from the existing literature on growth with learning. This happens when the market continuously observes a low TFP when using the decentralised production process. In this case, the central planner becomes very pessimistic and then abandon it, after which the market belief remains unchanged. We show that there exist two steady states, one corresponding to the decentralised sector as a production process, the other sticking to the old technology selection. Such a result is in contrast with the full information case since only one steady state emerges.[4]

This paper explores how an economy develops when a firm optimally adopts the quality of the production process from a decentralised sector, which can only be learned from quality-dependent outputs, until the production process of the centralised sector is applied. With the presence of evolving uncertainty and beliefs, deciding when and whether to adopt a production process becomes a key driver of economic growth and can explain differences in GDP per capita around the world, as documented by Caselli and Coleman (2001). However, a complete understanding of the dynamic process by which uncertainty and belief influence marketisation adoption decisions is lacking. To address this issue, we take a different approach from the existing literature, which focuses on a central planner's problem of learning the unknown state within one sector (see, for example, El-Gamal and Sundaram 1993; Nyarko and Olson, 1996; Koulovatianos et al., 2009; Mirman et al., 2016), and instead take a first step towards examining belief-driven production process adoption within a two-sector model.

In the study on economic growth with uncertainty, learning from experimentation has been emphasised as an important role on the equilibrium outcomes. Freixas (1981) studies a one-sector optimal growth model with uncertain production function. To improve the life-time wellbeing, a single agent treats the level of investment as a tool to learn the true production function. Similar papers (such as El-Gamal and Sundaram, 1993, Nyarko and Olson 1996, Kelly and Kolstad 1999, Bertocchi and Spagat, 1998, Koulovatianos et al., 2009 and Mirman et al., 2016.) embed the dynamic role of learning (passive or active) into different types of one-sector growth model. All of these works consider a central planner's problem, in which the central planner uses consumption and investment as experimentation in each period to learn the unknown state optimally and thus maximises the social welfare. The true state would always be learned eventually on the equilibrium path since experimentation is always exercised in each pe-

[4]See Zou (1994).

riod. In contrast, the central planner in our model, rather than choosing investment directly, decides whether to keep the experimental sector with unknown productivity and representative firm makes their own investment decision. In addition, the trust state cannot be learned once the decentralised sector is abandoned.

An other strand of literature looks at the gradualism of reform in China. While Chen and Zha (2025) provide a general approach by considering an extensive review of recent empirical literature on China's gradualist approach,[5] both Brunnermeier et al. (2017) and Li and Wang (2025) consider gradual reform and its optimality in the Chinese financial market. Indeed, Brunnermeier et al. (2017) develop an analytical framework to examine the persistence of China's gradualistic approach and offer a pessimistic perspective on its interaction with developed financial markets. Building on Brunnermeier et al. (2017), Li and Wang (2025) incorporate demand shocks and market equilibrium, and introduce the production role of financial markets. They provide an optimistic view, showing that the gradualistic approach can be both optimal and time-consistent. Compared to them, we provide a historical approach of the gradualism reform regarding marketisation as well as a simple dynamic macroeconomic model.

The rest of the paper is organised as follows. Section 2 discusses the gradualism of the Chinese transition to market economy. In Section 3 we present the model while in Section 4 we derive the optimal experimentation. Finally, section 5 concludes.

2. GRADUALISM & MARKETISATION

In this section we consider one aspect of the Chinese "take-off" in a historical perspective: the claimed gradualism in the adoption of an "all-market" model in China. This experiment of gradualism made China escape the shock therapy that experienced Russia and Eastern countries.

Our model first relies on a literature in economics, politics, political sociology, history and political anthropology that adresses this issue. We seek to formalise the Chinese reality, in light of the state of the art that emerges from this literature. Our aim is to model the stylised features exhibited in Weber (2021) and Chen and Zha (2025) which contributed to a renewed understanding of the possible trajectories of marketisation.

2.1. China experience of gradualism explain why China escaped shock therapy

"China's reform began not only without a blueprint for how to reform, but without even a sense of what the ultimate of reform should be" (Naughton,

[5] A deeper discussion of this paper is provided in section 2.1.

1995, p.99). At the beginning, the debate focused on the role of the plan and the possibility of introducing market elements. The conservative camp advocated the continuing primacy of planning over market. During the first year or two of the reform era, Chen Yun was the dominant economic policy maker. He had a strong experience as an economist and was famous for improving the economic situation after the dramatic policy of the great leap forward. He played a crucial role in the adoption of reorientation policy. He insisted that the plan must be primary and the market a secondary or supplementary element (Naughton, 1995). But quickly, Chen lost his influence and by the end of the 80's the conservatives became disquiet about the reforms and criticised them. On the other side, in the debate about combining plan and market, some economists were very reformist, like Wu Jinglian or Xue Muqiao and wanted to implement markets mechanisms largely and quickly. But Zhao Ziyang, Premier (from 1980 until 1987), having a strong experience of reforms as the governor of Sichuan province, became the main architect of the reforms with caution, flexibility and pragmatism. This point of view allowed the Chinese economy to escape overly cautious reforms or, on the contrary, shock therapy.

Weber (2021) shows that in the debate on reform in China, two camps were confronting each other: the advocates of a shock therapy "in one go" versus the tenants of gradualism. Gradualism meant no "blitz price reform" but a "planned" and "experimental gradualism" toward marketisation which defines a complete set of reform steps. Weber (2021) characterises the setup of this gradualism with an image: "make the path while walking", i.e. experimentation (the latter refers to words of Deng Xiaoping, literally, "cross the river by feeling your way stone by stone").

In China, the 1980s witnessed an explosion of independant economic decision-making by individuals (Nolan, 1988). Weber (2021) in her chapter 6, "Market creation versus price liberalisation", looks back on the stages of China's transition to a market economy *: "a dual-track price system was implemented that for instance allowed from 1984 the prices of some nonrationed producer goods to fluctuate within a 20% upward or downward deviation from the state-set-price. This cap should gradually or at once be abolished, depending on the concrete good."* She considers 1984 as a crucial date in the begining of the process since, from this date, market conditions drove the price-setting-practice. Indeed, "In 1984, for the first time, Zhao managed to create a large enough space for maneuver to give himself the freedom to implement significant economic reform" Naughton (1995), (p.178). The same year, on October 20, the Central Committee adopted the "Decision on Reform of the Economic Structure". Weber (2021) notes that from 1985, the price reform combined "adjusting with letting go and progress in small steps". Opening the market through this dual-track-price system meant the possibility of "both a return to a greater emphasis on the plan as well as a more radical shift to the market" (chapter 7).

Thanks to this gradual approach to changes, China obtained a political consensus to continue market reforms and the dual-track-price system became Chinese official policy. At that time in China, the issue "was not whether to reform but how to reform" (chapter 7). This conception of gradualism was opposed to the "one big step" approach defended by neoclassical economists, monetarists, and the Eastern European reformers. The uniqueness of China's "take-off" is that it relied on a pro-marketisation conception carried by the pragmatism of dual-track reformers, opposed to big bang theory of Eastern Europe and Russia reformers. Dual-track reformers adopted an empirical approach based on case – studies of local experiments and gradually extended these experiments. According to Weber (2021), this process enabled China to escape shock therapy (chapter 8). In 1987 and 1988, Zhao Ziyang's program was to extend gradualism to new frontiers: a new coastal marketisation was developped. The conclusion of Weber (2021) is very strong: "The domestic version of the dual-track system transformed China's socialist production units into market-oriented entreprises. The coastal-development strategy extended this approach to the global market. China's enterprises were not just marketised; they were to catch up with global capitalism" (p. 267). Ultimately, Weber (2021) recapitulates China's preference for gradualism as follows: "Instead of experiencing severe economic decline and deindustrialisation, as did Russia and other transition economies, China's dual-track reforms laid the institutional and structural foundations for its economic ascent under tight political control by the party and the State". China's "take-off" tells us a success story whereas the camp of the shock therapy doctrine of transition (the old system must be transformed in one go) that Russia experienced, in the 90's, at her expenses, failed.

Additionally, Chen and Zha (2025) provide an extensive review of recent empirical literature on China's gradualist approach. This is the richest and most recent source in all macroeconomic aspects. Most notably, the authors successively embrace : 1) Economic Barriers in Pre-1978 China (respectively, collective farming, the Hukou system, Exclusive SOEs, The Economy Closed to the Rest of the World, the absence of financial markets) ; 2) Sectoral Shifts ; 3) Ownership structure changes ; 4) Trade Liberalization ; 5) Foreign Direct Investment ; 6) The housing market privatization ; 7) Financial Liberalization, so many aspects that we do not address specifically in our model.

Our contribution to the analysis of gradualism complements Chen and Zha (2025) article by providing a theoretical model of the experience in question, namely by addressing the points 1, 2, 3 and 4 mentioned above. On the one hand, we propose a novel model of Chinese gradualism based on a dynamic theoretical two-sector model (a centralised sector and an experimental market sector) with a Bayesian learning process for the productivity levels of the experimental sector. Doing so, we are dealing, from a theoretical point of view, with a crucial point in the history of capitalism: How the transition from a planned economy to party-state capitalism took place in China? On the other hand, the second part of Chen and Zha (2025) article about the consequences of gradualism (raising notably the issues of 1) Global Imbalance and Trade War ; 2) Barriers in Transitioning to a Consumption-Led Growth Model ; 3) High saving rates ; 4) Growing inequalities ; 5) Credit Reversal and Looming Debt Challenges) falls outside the scope of our study, which addresses and models the steps involved in constructing gradualism rather than its consequences. However, the conclusion of Chen and Zha (2025) that 'future research could explore the potential impacts of alternative policy choices China did not pursue' and attempt to build counterfactuals to gradualism meets our future research agenda. For the moment, in the next section, we present our theoretical model of the making of Chinese gradualism towards marketisation.

2.2. Marketisation: The township and village enterprises to build markets

When Deng Xiaoping came to power, his two main goals were to maintain the Communist Party's control and to stimulate economic growth. In 1978, China was an impoverished nation with a predominantly agrarian population. Unlike the Union of Soviet Socialist Republics, China had no fixed model for reform. Deng's leadership focused on pragmatism, prioritising economic progress over ideological dogma (Renard, 2018).

At the time, China's agricultural sector faced four key challenges: artificially low procurement prices, the abolition of farm produce markets, inefficiencies due to large production teams, and a lack of specialisation (Lin, 2012). Since political reform was not an option, economic reforms were introduced gradually. This gradual approach helped navigate internal party conflicts and prevent destabilisation.

Reforms began in rural areas with small-scale experiments. The Third Plenary Session of the 11th Central Committee in 1978 initiated these changes. Three key measures were implemented: downsizing production teams to increase efficiency, raising farm prices to incentivise production, and reinstating farm product markets and transport networks. A key development was the emergence of the Household Responsibility System (HRS), originating from a village in Anhui Province. Farmers secretly divided collective land among households, producing exceptional results (Naughton, 2007). Despite its initial illegality, the government endorsed and promoted the system nationwide by 1981. By 1982, over 90% of agricultural households had adopted HRS, leading to increased grain production, exports, and labour efficiency. Surplus labour shifted to non-agricultural activities, fueling rural industrialisation.

A major outcome of rural reforms was the rise of Township and Village Enterprises (TVEs), which played a crucial role in China's transition to a market economy. Initially, China's constitution restricted private enterprise, but gradual amendments legitimised and integrated the non-state sector. "Rural enterprises grew up in the interstices of the command economy system" (Naughton, 1995). The 5th National People's Congress (1982) legitimised non-state enterprises, and subsequent constitutional amendments reinforced their role. TVEs thrived under China's regionally decentralised authoritarian regime, which combined centralised political control with economic decentralisation (Xu, 2011). Local governments, motivated by career incentives, actively promoted economic growth by supporting TVEs. They had autonomy over economic policies and were incentivised to drive growth. Officials competed for promotions based on economic performance, leading to the rapid expansion of TVEs. Unlike state-owned enterprises (SOEs), TVEs were flexible and profit-driven, operating with minimal state subsidies. Their cost-effective labour model allowed them to compete effectively against SOEs.

Local governments played a crucial role in TVEs' success, compensating for the lack of well-defined property rights which makes the peculiarity of the Chinese experience to transition.[6] "The surprising thing with TVEs is not that they function without clearly specified property rights, but rather the fact that local government ownership turns out to be a fairly robust ownership form" (Naughton, 1994, p.268)). They controlled profits, appointed managers, and facilitated financial intermediation by acting as guarantors to banks. Between 1978 and the mid-1990s, TVEs were the most dynamic sector of China's economy, driving growth through productivity rather than privatisation. Their emergence signified an evolutionary transition from a planned economy to a market-based system.[7] Reforms were experimental, with no predefined endpoint, adapting over time through trial and error.

However, the rise of private enterprises and economic liberalisation led to TVEs' decline (Kung and Lin, 2007). Increased migration to coastal regions and rising competition from private and foreign firms weakened their dominance. As restrictions on private firms eased, TVEs struggled to compete. Despite their eventual decline, TVEs played a crucial role in China's transition to a market economy, illustrating the success of China's gradual, experimental approach to reform. In summary, China's economic transformation under Deng Xiaoping was characterised by gradual, prag-

[6]Let us recall that the strong political centralisation was accompanied by a strong economic decentralisation (Xu, 2011).

[7]See Fu et al. (2022) for an evolutionary model discussing this point.

matic reforms. The success of rural reforms and TVEs facilitated China's shift from a centrally planned to a market-oriented economy. The decentralised yet authoritarian governance model enabled local experimentation while maintaining political control. Though TVEs initially drove economic growth, evolving market conditions eventually led to their decline, paving the way for private enterprise dominance. The great originality of the Chinese experience, which is unique in the world, is that it has experimented with a 'trial and error' transition to capitalism and the market economy, in the form of gradualism through marketisation, not with brutal privatisation. This is what our explanatory model captures as closely as possible in the next section.

3. MODEL

3.1. The Economy

To best illustrate this history of reform, we consider a two-sector infinite horizon economy, where time $t = 0, 1, \ldots$ is discrete. The first sector is "centralised sector", where the representative firm, a *SOE*, produces consumption goods by using a technology with a known TFP: $\hat{y} = \hat{A}\hat{l}_d^{\hat{s}}$. In this sector, the central planner decides to produce $\hat{y}$ through centralised channel at price $\hat{p}$, and the corresponding wage rate is $\hat{w} = \hat{p}\hat{A}\hat{s}\hat{l}_d^{\hat{s}-1}$.

The second sector is called "experimental sector". In such a sector a dual-track is implemented, i.e. part of production is sold through a centralised channel at price $\tilde{p}$ and the remaining in the market at price p_t. Our previous section emphasises the role of *SOE* and *TVE*, the representative firms in this sector represents such a mixture of the two types of firms where *SOE* will use the dual-track while the *TVE* sell all productions made through the market.

To formalize the model, we first characterize the segment of output allocated through the centralised channel. As in the "centralised sector", the representative firm, an *SOE*, produces consumption goods by using a technology with a known TFP: $\tilde{y} = \tilde{A}\tilde{l}_d^{\tilde{s}}$. The central planner decides to produce $\tilde{y}$ through centralised channel at price $\tilde{p}$, and the corresponding wage rate is $\tilde{w} = \tilde{p}\tilde{A}\tilde{s}\tilde{l}_d^{\tilde{s}-1}$. Next, we describe the portion of production transacted through the market. Here, the production technology in the market is initially unknown, which is either good or bad, $A \in \{A_g, A_b\}$, where

$$A_g = \begin{cases} \overline{A} & \text{with probability } \theta \\ \underline{A} & \text{with probability } 1-\theta \end{cases} \quad \text{and} \quad A_b = \underline{A}. \tag{1}$$

Intuitively, a good technology in the market of "experimental sector" has a random TFP, which could achieve a high TFP, $\overline{A}$, with probability $\theta \in (0, 1)$, while a bad one always yields a low TFP, $\underline{A}$. In period, t the representative firm believes the technology in the "experimental sector" is good with probability $q_t \in (0,1]$. Such a belief is shaped by the history of realised output from the "experimental sector". Such TFP reflects the transaction cost (all social costs) of using the market. In particular, a high transaction cost corresponds to a low TFP which could be due to several social factors, such as local lobbies, leading the market to be not so effective. As an example of transaction costs, local governments have engaged in protectionist practices due to their reliance on local enterprises for their fiscal revenues. Imposing informal "tariffs" on goods originating from other provinces, local government effectively created additional transaction costs for external firms. Although such practices were officially prohibited, they remained common in practice (Naughton, 1995, p.232).

Both the belief and the probability of a good technology in the market increase the expected TFP and thus the likelihood of marketisation increases. We apply the following assumptions to restrict values of TFP, making the decentalised production process with a higher ex ante expected TFP than the centralised one.

ASSUMPTION 1. $\overline{A} > \tilde{A} > \underline{A} > 0$ *and* $q_0\theta\overline{A} + (1-q_0\theta)\underline{A} > \tilde{A}$.

The decentralised production process of the market in the "experimental sector" can be expressed as

$$y_t = A(q_t) l_{d,t}^s, \tag{2}$$

where $l_{d,t}$ is the labour demand used in the market, and $A(q_t)$ represents the realised TFP and its expected value is given by $q_t\theta\overline{A} + (1-q_t\theta)\underline{A}$. In this sector, the part of the production dealt by the central channel is $\tilde{y}$ and sold at price $\tilde{p}$ and with a cost $\tilde{w}$ of labour wages. The production function is $\tilde{y} = \tilde{A}\tilde{l}_d^{\tilde{s}}$. The part of the production dealt by the market is y_t and sold at price p_t with a cost of labour $w_t l_{d,t}$. It follows that the profit function is $p_t y_t + \tilde{p}\tilde{y} - \tilde{w}\tilde{l}_d - w_t l_{d,t}$, and the corresponding wage is

$$w_t = s p_t A(q_t) l_{d,t}^{s-1}. \tag{3}$$

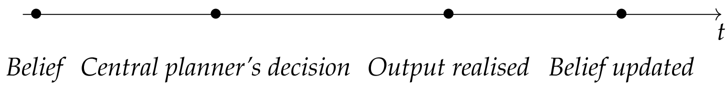
The central planner maximises the expected life-time production values in this economy by deciding whether to keep the market in the "experimental sector" in period t:

$$\max_{\mathbf{1}_t \in \{0,1\}} E\left[\sum_{t=0}^{\infty} \beta^t \left[\hat{p}\hat{y} + \tilde{p}\tilde{y} + \mathbf{1}_t \left(p_t y_t - \tilde{p}\tilde{y}\right)\right]\right]. \tag{4}$$

When $\mathbf{1}_t = 1$, the central planner keeps the the market of "experimental sector" in period t and hence a representative firm interacts with other parties in the market by exercising the new technology with unknown quality. When $\mathbf{1}_t = 0$, the planer closes down the market of the "experimental sector" and hence all goods are produced in a centralised way.

The timing of the model is shown in Figure 1.

FIG. 1. Timing of the model.



3.2. Household

The economy is populated by a continuum of identical individuals, normalised to unit mass. Denote $\hat{l}_s$, the fixed labour supply in the "centralised sector" and $\tilde{l}_s$ the fixed labour supply in the centrally planned component of the "experimental sector". Let $l_{s,t}$ denote the variable labour supply in the decentralised producing part of the "experimental sector", and $\mathcal{L}_s \equiv \tilde{l}_s + \hat{l}_s$ denote the total fixed labour supply. Let H_t denote the total labour supplied made available by households at time t. Then it holds that, $l_{s,t} + \mathcal{L}_s = H_t$, implying $l_{s_t} \in (0, H_t - \mathcal{L}_s)$.

The preferences of the representative household depend on the consumption from both sectors: $\tilde{c}$ and c_t represent consumption of goods produced in the "experimental sector", while $\hat{c}$ denotes consumption from the centralised sector. Disutility arises from supplying labour to both the fixed component ($\mathcal{L}_s$) and the market ($l_{s,t}$). The household's decision problem involves choosing the market consumption good c_t and the variable labour supply $l_{s,t}$ to maximise utility, given the consumption and labour supply in the centralized planning process, namely $\tilde{c}$ and $\hat{c}$, and $\mathcal{L}_s$. Such preferences are described by the following intertemporal utility function:[8]

$$\sum_{t=0}^{+\infty} \beta^t \left[(\tilde{c} + c_t)^\gamma \hat{c}^{1-\gamma} - \frac{l_{s,t}^{1+\frac{1}{\varepsilon_l}}}{1 + \frac{1}{\varepsilon_l}} - \mathcal{L}_s \right], \tag{5}$$

where γ is the share of consumption good from the decentralised production and ε_l is the elasticity of labour supply. At each period, the representative agent consumes consumption goods from the two sectors and he/she finances his/her expenditures out of labour income. When maximising the utility function given by (5), the representative agent must respect the budget constraint which is

$$w_t l_{s,t} + \hat{w}\hat{l}_s + \tilde{w}\tilde{l}_s = p_t c_t + \tilde{p}\tilde{c} + \hat{p}\hat{c}. \tag{6}$$

[8]A more detailed Dual-Price Demand Theory is given in Liu and Song (2003).

The first-order conditions lead to the consumption-labour choice

$$l_{s,t}^{\frac{1}{\varepsilon_l}} = \tfrac{w_t}{p_t}\gamma(\tilde{c}+c_t)^{\gamma-1}\hat{c}^{1-\gamma}, \tag{7}$$

and the demand for the market good, c_t:

$$p_t c_t = \gamma\left[w_t l_{s,t} + \hat{w}\hat{l}_s + \tilde{w}\tilde{l}_s - \left(\tilde{p} + \tfrac{1-\gamma}{\gamma}p_t\right)\tilde{c}\right]. \tag{8}$$

This demand for market good decreases given an increase in plan ration quotas, $\tilde{c}$, and price quotas, $\tilde{p}$. Plugging (8) into (7), the labour supply $l_{s,t}$ is

$$l_{s,t} = \left[\gamma^{\gamma}(1-\gamma)^{1-\gamma}\frac{w_t}{p_t}\left(\frac{p_t}{\hat{p}}\right)^{1-\gamma}\right]^{\varepsilon_l}. \tag{9}$$

3.3. Learning

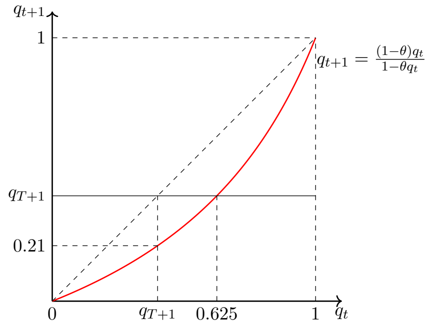
The realised production in each period is observable in the beginning of period t. Let $Q(n, t-n)$ denote the posterior belief of the new technology in the market of the "experimental sector" being good given a high TFP has been inferred n times in the past t experiments, where $0 \leq n \leq t$. Notice that the high TFP is conclusive good news in our model, the posterior belief has the following feature: for $n \geq 1$, $Q(n, t-n) = 1$; instead, if $n = 0$, the representative firms belief are updated in a Bayes fashion:

$$Q(0,t) = \frac{q_0(1-\theta)^t}{q_0(1-\theta)^t + 1 - q_0} \equiv q_t. \tag{10}$$

Intuitively, in our model, if $\overline{A}$ has been inferred in the past from the realised outputs and the corresponding inputs in the "experimental sector" it is believed that the market of the "experimental sector" must have an effective production process, and this degenerate belief remains unchanged. Instead, if only $\underline{A}$ is inferred, the belief of the technology in market of the "experimental sector" being good shrinks. Figure 2 illustrates an example of belief updating where $\overline{A}$ in the market of the "experimental sector" has not been inferred as time goes by.

Since the market of the "experimental sector" is preferred only when its existence can generate higher life-time discounted expected profit, the lower posterior beliefs makes the "experimental sector" less attractive. As a result, there exists a threshold belief such that the central planner is not willing to operate the "experimental sector". Let T be last period of experimentation given $\overline{A}$ has not been inferred so far, after which the market of the "experimental sector" will be closed. It is also worth noting

FIG. 2. Belief (q_t, q_{t+1}) with the threshold $\tilde{q}$ (example: $\theta = 0.6$ and $q_{T+1} = 0.4$).



that the posterior belief evolves only if the market of the "experimental sector" remains operational. Otherwise, the belief remains unchanged.

4. OPTIMAL EXPERIMENTATION

In equilibrium the representative household maximises her/his utility, the representative firm, SOE, in the "centralised sector" produces consumption goods according to the plan of the central planner while the representative firm in the "experimental sector" produces according to a dual-track process. In the first track, the representative firms produce consumption goods according to the plan of the central planner while in the second track, the representative firms maximise profit. In each period t there are two markets which need to be simultaneously at equilibrium: the consumption good produced in the "experimental sector", the consumption good centralised one. One immediately verifies that equilibrium in the consumption good in the "experimental sector" requires $p_t y_t + \tilde{p}\tilde{y} = p_t c_t + \tilde{p}\tilde{c}$ in each period t, while the consumption good in the centralised sector requires $\hat{y} = \hat{c}$.

Consider, now, the labour market. Households must allocate and supply a fixed amount of labour either in the "centralised sector", $\hat{l}_s$, or in centralised production process of the "experimental sector" in the , $\tilde{l}_s$. It follows that $\hat{w}$ and $\tilde{w}$ may equalise or not. All households with available time will participate in the decentralised production process of the "experimental sector" and the remaining labour supplied from households in such sector is $l_{s,t}$. The labour market equilibrium is characterised by the following conditions. In the "centralised sector" and in the centralised production process of the "experimental sector", employment is fixed at $\hat{l}_d = \hat{l}_s$ and $\tilde{l}_d = \tilde{l}_s$, with wages determined by their respective production technologies: $\hat{w} = \hat{A}\hat{p}\hat{s}\hat{l}_s^{\hat{s}-1}$ and $\tilde{w} = \tilde{A}\tilde{p}\tilde{s}\tilde{l}_s^{\tilde{s}-1}$. The variable labour supply available in the decentralised production process of the "experimental sector" is $l_{s,t} = H_t - \mathcal{L}_s$ and (9). In such a sector, the labour demand $l_{d,t}$ follows from its production function $y_t = A(q_t)l_{d,t}^s$, with the wage given by $w_t = sp_tA(q_t)l_{d,t}^{s-1}$. Labour market clearing condition in such market requires $l_{d,t} = l_{s,t} = H_t - \mathcal{L}_s$, which determines the equilibrium wage $w_t^* = sp_tA(q_t)(H_t - \mathcal{L}_s)^{s-1}$. This model captures constrained labour mobility where households maintain primary employment while engaging the decentralised production process of the "experimental sector". In the remaining, we will assume that the wage rate in the decentralised production process of the "experimental sector" is proportional to the one of the centralised production process of the same sector, i.e. $w_t = \delta\tilde{w}$ with $\delta > 0$.

Taking into account the belief updating by (10), the labour supply defined in (9), and the wage, the following expression determines the dynamics of the economy, driven only by the evolution of beliefs:

$$l_{s,t} = \left[\gamma^\gamma(1-\gamma)^{1-\gamma}\frac{w_t}{p_t}\left(\frac{p_t}{\hat{p}}\right)^{1-\gamma}\right]^{\varepsilon_l} \qquad \text{and} \qquad (10). \tag{11}$$

Such equations show that the current labour supply in the "experimental sector" depends upon the belief evolution.

At the steady state, the existence of the market of the "experimental sector" depends on both beliefs about its technology and the underlying learning process. Our model features two possible steady states: a centralised economy and a market-oriented economy. In the centralised economy, beliefs about the quality of technology in the market of the "experimental sector" remain persistently low and unchanged, leading to its closure and exclusive reliance on centralised production. In contrast, in the market-oriented economy economy, the learning process reveals that the technology in the market of the "experimental sector" is effective, ensuring its continued existence. In this case, the expected TFP is given by $\theta\overline{A} + (1-\theta)\underline{A}$ meaning that θ, the probability that the TFP is high, influences labour supply and other key variables governing the steady state.[9]

We, now, consider the optimal experimentation. Since the learning process, or experimentation, occurs only when $t < T-1$, the central planner's optimal choice on $\{\mathbf{1}_t\}_{t=0}^{\infty}$ is equivalent to find the optimal stopping time T^*+1 such that $\mathbf{1}_t^* = 1$ for $t \leq T^*$ and $\mathbf{1}_t^* = 0$ for $t \geq T^*+1$. The central planner's maximisation problem (4) can be simplified by incorporating the

[9]Notably, in the absence of uncertainty (and the learning process), there would be only a single stationary solution under full information.

market-clearing conditions for each period:[10]

$$\max_{T\in\mathbb{N}} \quad \mathrm{V}(T) = \sum_{t=0}^{T-1} \beta^t p_t(q_t) l_t^s(q_t) \left[q_0(1-\theta)^t + 1 - q_0\right] \left[q_t\theta(\overline{A}-\underline{A}) + \underline{A}\right] + \frac{\hat{p}\hat{y}}{1-\beta}$$
$$+ q_0\theta \frac{1-\beta^T(1-\theta)^T}{1-\beta(1-\theta)} \frac{\beta}{1-\beta} \left[\theta(\overline{A}-\underline{A}) + \underline{A}\right] p(1) l^s(1)$$
$$+ \left[q_0(1-\theta)^T + 1 - q_0\right] \frac{\beta^T \tilde{p}\tilde{y}}{1-\beta}, \tag{12}$$

where

$$p_t(q_t) = \frac{\delta\tilde{s}\tilde{p}\tilde{A}\tilde{l}^{\tilde{s}-1}}{sA(q_t)l_s(q_t)^{s-1}}$$
$$\text{and} \qquad l_s(q_t) = \left[[s\gamma A(q_t)]^\gamma \left[\frac{(1-\gamma)\delta\tilde{A}\tilde{s}\tilde{p}\tilde{l}^{\tilde{s}-1}}{\hat{p}} \right]^{1-\gamma} \right]^{\frac{\varepsilon_l}{1+(1-s)\gamma\varepsilon_l}}. \tag{13}$$

The first difference of (12) then yields

$$\mathrm{V}(T) - \mathrm{V}(T-1) \propto p_{T-1}(q_{T-1}) y_{T-1}(q_{T-1}) + \beta \frac{q_{T-1}\theta\left(p(1)y(1) - \tilde{p}\tilde{y}\right)}{1-\beta} - \beta\tilde{p}\tilde{y}. \tag{14}$$

It is easy to see that as the central planner's belief diminishes, expression (14) decreases, thereby reducing the marginal net benefit of experimentation in the market of the "experimental sector". Consequently, the following assumption ensures the existence of an optimal stopping time.

Assumption 2. $p(0)\underline{A}l^s(0) < \tilde{p}\tilde{y} \leq \frac{p_0(q_0)y_0(q_0)}{\beta} + \frac{q_0\theta(p(1)y(1)-\tilde{p}\tilde{y})}{1-\beta}$.

The first inequality in Assumption 2 indicates that the central planner will not experiment indefinitely, while the second guarantees that the central planner experiments at least once. As a result, the optimal stopping time of experimentation is summarised in the following proposition.

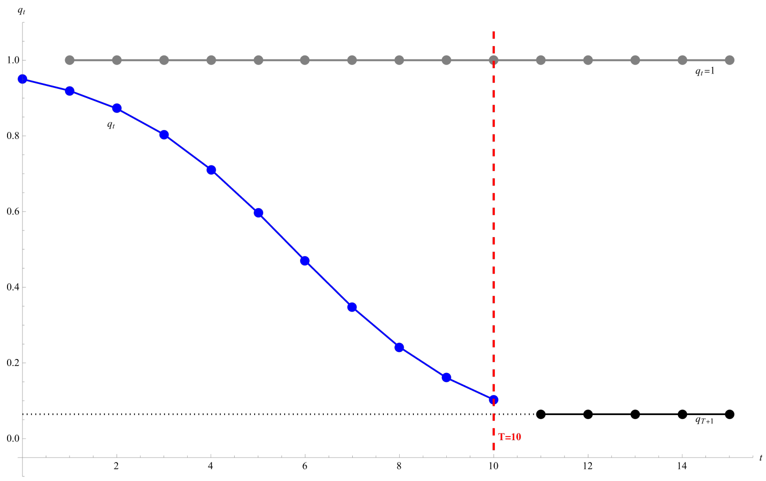
Proposition 1. *Given Assumption 1 and 2, the optimal stopping time of experimentation in the "experimental sector" T^*+1, is given by*

$$T^* = \max\left\{ T \in \mathbb{N} : p_{T-1}(q_{T-1}) y_{T-1}(q_{T-1}) + \beta \frac{q_{T-1}\theta\left(p(1)y(1)-\tilde{p}\tilde{y}\right)}{1-\beta} \geq \beta\tilde{p}\tilde{y} \right\}. \tag{15}$$

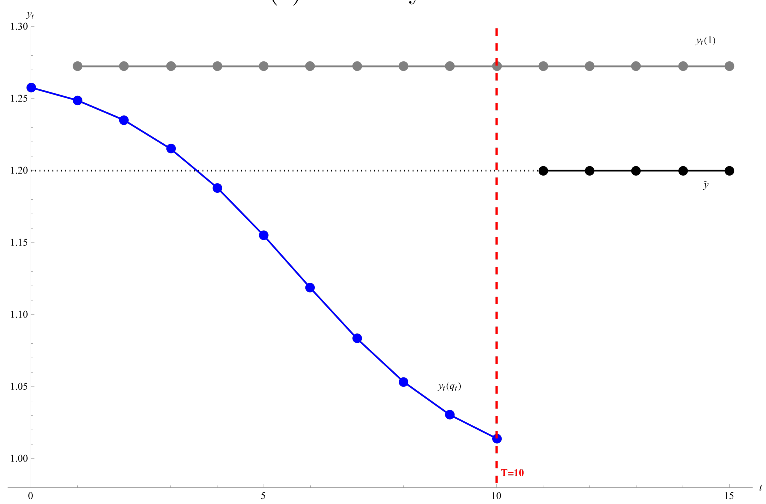
[10] The expression before the simplification is shown in the Appendix 1.

Proof. It is straightforward from (14). ▌

FIG. 3. Evolution of Beliefs



(a) Belief dynamics



(b) Expected output dynamics

The optimal stopping time in Proposition 1 implies that the central planner is willing to tolerate a lower periodic value than that of the centralised economy while experimenting in the “experimental sector”. Specifically,

(15) indicates that $p_{T^*}y_{T^*}(q_{T^*}) < \tilde{p}\tilde{y}$.[11] In this period, the central planner allows an additional opportunity to achieve a higher TFP, which has the potential to elevate future values. The advantages gained from this increase could outweigh any current losses incurred.[12]

The initial conditions for the values of q_0, initial belief, and θ, the probability that the TFP is high, will determine whether the market is closed down or remains operational. Specifically, with probability $1 - q_0\left[1-(1-\theta)^T\right]$, $\overline{A}$ is not inferred during the learning process. In this case, the market is shut down, and production takes place in a centralised manner. Conversely, with probability $q_0\left[1-(1-\theta)^T\right]$, $\overline{A}$ is inferred before the final period of experimentation, allowing the market of the "experimental sector" to succeed and marketisation to be adopted. The likelihood ratio of the new technology being adopted in equilibrium is:

$$LR|_{\overline{A}} = \frac{q_0\left[1-(1-\theta)^T\right]}{1-q_0\left[1-(1-\theta)^T\right]}. \tag{16}$$

Proposition 1 also indicates that the transitional dynamics of the economy will either converge to a centralised economy or transition to a market-oriented economy, depending on beliefs about the quality of technology in the "experimental sector". Multiple equilibria imply that central planner finds it rational to produce either centrally or through the market. When the belief is sufficiently low, the economy falls into a centralised economy, even if the true quality of technology in the market of the "experimental sector" is high. Once in this trap, the belief remains too low to justify experimentation, making escape impossible. Above the threshold, the economy fluctuates depending on whether agents coordinate their beliefs at a higher level. The existence of this belief threshold also implies that if the initial belief is too low, the central planner will not undertake any experimentation.

The following table summarises the calibration of the structural parameters used: $\overline{A}$, $\underline{A}$ and $\hat{A}$ should satisfy assumption 1, so we consider $\overline{A} = 1.6$, $\underline{A} = 1$ and $\hat{A} = 1.2$.

TABLE 1.

Calibration.

ε_l	$s = \hat{s}$	$\overline{A}$	$\underline{A}$	$\tilde{A}$	γ	β	q_0	θ	δ	$\tilde{p}$	$\hat{p}$
2.8	0.35	1.6	1	1.2	0.3	0.96	0.95	0.4	0.95	1	0.11

[11] Remark that $p_{T^*}y_{T^*}(q_{T^*}) - \tilde{p}\tilde{y} < -\beta\frac{q_{T^*}\theta(p(1)y(1)-\tilde{p}\tilde{y})}{1-\beta} < 0$.

[12] This feature makes a significant difference from Fu and Le Riche (2021), in which the experimentation only emerge when the expected periodic net value from experimentation is non-negative.

Figures 3(a) and 3(b) present a numerical example illustrating the evolution of the posterior belief and the expected output dynamics, respectively. The blue points represent values during experimentation periods, the grey points correspond to values in a market-oriented economy, and the black points indicate values in a centralised economy. In our numerical example, the central planner optimally experiments the “experimental sector” till $T^* = 10$ years. When $1 > q_t \geq q_{T^*}$, in period $t+1$, the market belief either jumps to 1 on the grey line with probability $q_t(1-\theta)$ and remains unchanged, or drops to q_{t+1} with probability $1 - q_t\theta$. This learning process carries on till period T^*, after which the market belief remains as 1.

5. CONCLUDING REMARKS

In this paper, relying on historical evidence of the Chinese gradualism toward marketisation, we have developed a two-sector dynamic model of the Chinese gradualism and marketisation, where two consumption goods are produced. In one sector, production of the consumption good is made through a centralised process, while in the other sector, called the “experimental sector”, a dual production process is performed, through a centralised process and a decentralised process. In the “experimental sector”, the quality of the decentralised production process is unknown and the central planner experiments, through a trial and error process, whether marketisation is possible or not. We have shown that when transaction costs (e.g. local lobbies) to implement are low, the central planner will decide to give more and more importance to the decentralised production process and thus marketisation occurs. Eventually, our model captures the features of China’s historical smooth phase transition from a planned economy to a market economy, through the lens of a trial and error information-learning process on revealed productivity levels of the “experimental sector”.

APPENDIX A

In this appendix, we present some details of our equations. The maximisation problem in (4) yields the following optimal stopping problem

$$
\begin{aligned}
&\max_{T\in\mathbb{N}} \mathrm{V}(T)\\
=&q_0\theta\left\{p_0(q_0)\overline{A}l_0^s(q_0)+\sum_{t=1}^{\infty}\beta^t\left[\theta\overline{A}+(1-\theta)\underline{A}\right]p_t(1)l_t^s(1)\right\}\\
&+(1-q_0\theta)\left\{p_0(q_0)\underline{A}l_0^s(q_0)+\beta q_1\theta\left\{p_1(q_1)\overline{A}l_1^s(q_1)+\sum_{t=1}^{\infty}\beta^t\left[\theta\overline{A}+(1-\theta)\underline{A}\right]p_{t+1}(1)l_{t+1}^s(1)\right\}\right\}\\
&+(1-q_0\theta)(1-q_1\theta)\beta\left\{p_1(q_1)\underline{A}l_1^s(q_1)\right.\\
&+\beta q_2\theta\left\{p_2(q_2)\overline{A}l_2^s(q_2)+\sum_{t=1}^{\infty}\beta^t\left[\theta\overline{A}+(1-\theta)\underline{A}\right]p_{t+2}(1)l_{t+2}^s(1)\right\}\Bigg\}\\
&+\dots\\
&+(1-q_0\theta)\cdots(1-q_{T-2}\theta)\beta^{T-2}\left\{p_{T-2}(q_{T-2})\underline{A}l_{T-2}^s(q_{T-2})\right.\\
&+\beta q_{T-1}\theta\left\{p_{T-1}(q_{T-1})\overline{A}l_{T-1}^s(q_{T-1})+\sum_{t=1}^{\infty}\beta^t\left[\theta\overline{A}+(1-\theta)\underline{A}\right]p_{t+T-1}(1)l_{t+T-1}^s(1)\right\}\Bigg\}\\
&+(1-q_0\theta)\cdots(1-q_{T-1}\theta)\beta^{T-1}\left\{p_{T-1}(q_{T-1})\underline{A}l_{T-1}^s(q_1)+\beta\frac{\tilde{p}\tilde{y}}{1-\beta}\right\}+\frac{\hat{p}\hat{y}}{1-\beta}
\end{aligned}
\tag{A.1}
$$

From the market conditions, for $\forall t\neq t'$, it always hold that $l_t(1)=l_{t'}(1)\equiv l(1)$ and $p_t(1)=p_{t'}(1)\equiv p(1)$.

By taking the first difference, it yields that

$$
\begin{aligned}
&\mathrm{V}(T)-\mathrm{V}(T-1)\\
\propto&p_{T-1}(q_{T-1})l_{T-1}^s(q_{T-1})\left[q_0(1-\theta)^{T-1}+1-q_0\right]\left[q_{T-1}\theta(\overline{A}-\underline{A})+\underline{A}\right]\\
&+q_0\theta(1-\theta)^{T-1}\frac{\beta}{1-\beta}\left[\theta(\overline{A}-\underline{A})+\underline{A}\right]p(1)l^s(1)\\
&-\left\{q_0(1-\theta)^{T-1}\left[1-\beta(1-\theta)\right]+(1-q_0)(1-\beta)\right\}\frac{\tilde{p}\tilde{y}}{1-\beta}\\
\propto&p_{T-1}(q_{T-1})l_{T-1}^s(q_{T-1})\left[q_{T-1}\theta(\overline{A}-\underline{A})+\underline{A}\right]+q_{T-1}\theta\frac{\beta\left[\theta(\overline{A}-\underline{A})+\underline{A}\right]p(1)l^s(1)}{1-\beta}\\
&-(\beta q_{T-1}\theta+1-\beta)\frac{\tilde{p}\tilde{y}}{1-\beta}.
\end{aligned}
\tag{A.2}
$$

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