

A Stylized Model of China's Growth Since 1978

Linda Glawe^a and Helmut Wagner^b

Abstract. This paper develops a stylized multi-sector growth model of China's economy. We choose a neoclassical modeling approach and focus on the reform process under Deng Xiaoping as China's main growth driver since 1978. Following the literature, we distinguish between three major reform periods, namely the agricultural (1978–1984), the industrial (1984–1992) and the foreign-trade reform period (1992–present). Reflecting the neoclassical view, our model explains China's growth process since 1978 as a sequence of transitory growth phases generated by the reforms. We discuss our model's implications for China's future growth and the middle-income trap as well as growth-stimulating policies in China.

Keywords: multi-sector growth modeling, neoclassical growth theory, structural change, China, middle-income trap

JEL Classification: O10, O11, O40, O41

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1 Introduction

The recent literature discusses a potential growth slowdown in China, in particular the possibility that China will enter a middle-income trap (MIT) in the near future.² The term MIT refers to the often-observed case of a developing country's growth rate decreasing significantly when the country reaches the middle-income range.³ Obviously, the question of whether China, which has reached the middle-income range, will face an MIT in the near future is of the utmost importance not only for the Chinese population but also for the world economy as a whole. While the greatest part of the MIT literature (related to China) is rather of an empirical nature, our paper seeks to make a theoretical contribution to the discussion of future growth in China by suggesting a growth model of China and discussing its predictions for future growth and growth-generating policies.

Growth theory encompasses many schools of thought and many different models, which contradict each other to some extent. Thus, an ideological choice seems to be inevitable when modeling the growth process (of China). In our paper we choose a rather conservative branch: the neoclassical growth theory.⁴ While this decision is to a certain degree arbitrary and future research should develop models of China's growth following the other schools of growth theory, our choice of neoclassical growth theory has several advantages. First, it is one of the major schools of thought and is accepted among scholars (see for example Mankiw et al., 1992 on the feasibility of neoclassical growth models to explain empirical facts). Second, in contrast to many endogenous growth theories, the neoclassical view of the growth process is rather pessimistic (for example capital accumulation and factor reallocation can generate only transitory growth effects). Thus, it is important to include the predictions of the neoclassical school (as a rather conservative benchmark) in a portfolio of model predictions when assessing the future growth of China.

¹ Our special thanks are due to Denis Stijepic for his helpful comments.

² See Glawe and Wagner (2017) for a detailed discussion and analysis of the probability of a Chinese MIT.

³ For an overview of the MIT concept, see Glawe and Wagner (2016).

⁴ In previous research Song et al. (2011) and Gong (2016) suggest neoclassical growth models of China's economy. Song et al. (2011) focus on financial and contractual imperfections, the post-1992 transition and, in particular, the factor and labor reallocation *within* the manufacturing sector. Gong (2016) focuses on modeling two stages of economic development. In contrast to this literature, our model covers the entire Chinese reform period since 1978. Moreover, we focus on the effects of the reforms in a multi-sector framework.

The core idea of our paper is based on the model by Dabús et al. (2016), who develop a growth model of Argentina explaining Argentina's high pre-MIT growth and low growth in the MIT (see Section 4). To develop a (neoclassical) model of China's growth since 1978, we proceed as follows. First, we discuss the Deng Xiaoping reforms since 1978 and classify them into phases, showing that the first phase targeted the agricultural sector, the second phase targeted the manufacturing sector and the third phase focused on foreign direct investment (FDI). Moreover, we consider the empirical macro evidence on sector dynamics, factor accumulation and growth drivers (that is we discuss the results of growth regressions). Based on the lessons from this discussion, we choose a (neoclassical) multi-sector growth model with labor, capital, land and agricultural intermediates as input factors. The model is based on the modern neoclassical multi-sector modeling literature, among others Laitner (2000), Kongsamut et al. (2001), Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008). Nevertheless, our model departs significantly from this literature, since China was a centralized/planned socialist economy during the first reform phases; thus, it is necessary to adapt the decentralized/market economy results of the standard structural change models to China's case. We parameterize the model on the basis of the empirical evidence. Then, we discuss the effects of the reforms since 1978 on our model parameters, derive the parameter change sequences and study their effects on the sector structure, factor accumulation and per capita GDP growth in our model; overall, we derive the growth path of China since 1978, as predicted by our model. Finally, we discuss the growth prediction of the model and its interpretation as an MIT model in China's case.

The rest of the paper is structured as follows. In the next section, we discuss the Deng Xiaoping reforms and the macro evidence. In Section 3, we present the model. Section 4 is devoted to the interpretation of our model as an MIT model. Concluding remarks are provided in Section 5.

2 Empirical data and stylized facts

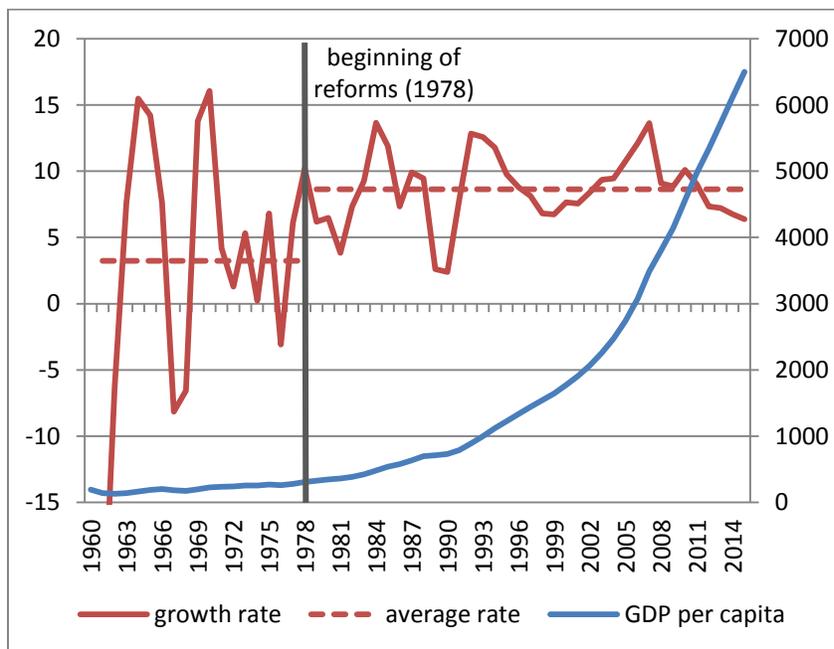
This section provides a brief description of China's economic development process since 1978. In subsection 2.1 we first compile some general stylized facts on China's economic performance on the basis of macroeconomic data before discussing and classifying the main economic reforms initiated by Deng Xiaoping in subsection 2.2.

2.1 Macroeconomic data

The macroeconomic data on China's economic development reveal the following stylized facts:

1. *GDP per capita growth*: During the reform period, there was a dramatic increase in the GDP per capita (see Figure 1). Prior to the reforms, the per capita income grew at an annual rate of approximately 3.25 percent, whereas the GDP per capita growth accelerated to an average of 8.62 percent between 1979 and 2015 (World Bank 2017, own calculations).

Figure 1 China's GDP per capita (constant US dollars) and GDP per capita growth (as percentages).



Data Source: World Bank (2017).

2. *Physical capital accumulation*: Around 1978 China had a positive capital accumulation rate, and capital accumulation was a major contributor to the GDP growth. The growth rate of physical capital (and its share in the GDP growth) increased continuously during the reform period and soared especially after 1992, when China intensified its efforts to open to the world and attract foreign direct investment (FDI). For empirical evidence see, among others, Hu and Khan (1997), Wang and Yao (2003), Maddison (2007), Bosworth and Collins (2008), Perkins and Rawski (2008), Zhang (2008), Whalley and Zhao (2010) and Wu (2011).

3. *Human capital accumulation*: Human capital accumulation was relatively slow and contributed only a little to the GDP growth over the reform period (see for example Wang and Yao, 2003; Perkins and Rawski, 2008; Wu, 2011; Zhu, 2012).
4. *Total factor productivity (TFP) growth*: After very low (and, according to some estimates, even negative) TFP growth rates in the years prior to the reforms, there has been a significant increase in the TFP growth since 1978. An analogous trend can be observed for the contribution of TFP to the overall GDP growth. For empirical evidence see Maddison (2007), Perkins and Rawski (2008) and Zhu (2012). Heytens and Zebregs (2003) provide a summary of older studies.
5. *Sectoral TFP growth*: On the sectoral level, the literature agrees that there were significant increases in agricultural productivity during the first reform phase (see Lin 1992, McMillan et al. 2000, Zheng et al. 2009), followed by increases in industrial (non-state) TFP growth during the second reform phase (see Weitzman and Xu, 1994; Jefferson et al., 2000; Zheng et al., 2009; see also Section 2.2).⁵
6. *Population growth*: Over the reform period, the average growth rate of Chinese population was around 1 percent p.a. (National Bureau of Statistics of China, NBS, own calculations).

Table 1 Sectoral employment shares in China (as percentages of the total employment).

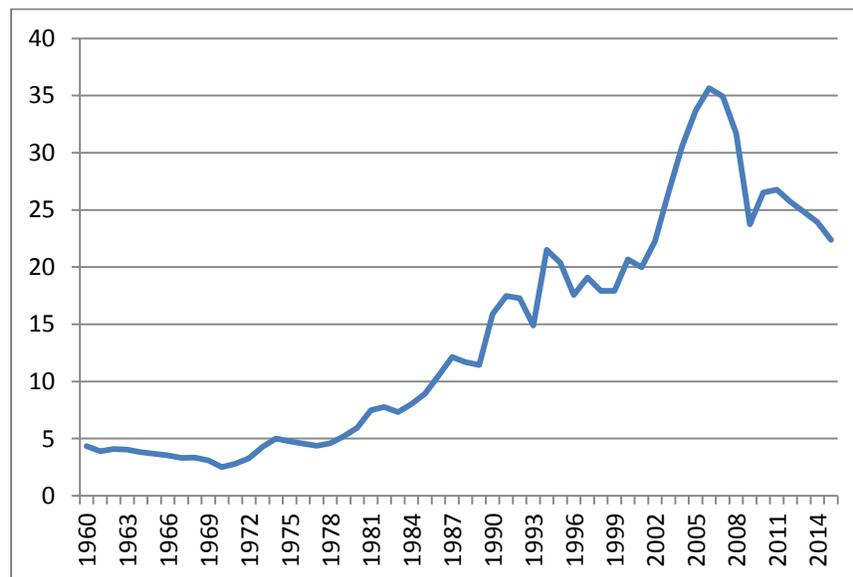
	Agriculture	Industry	Services
1978	70.53	17.30	12.18
1980	68.75	18.19	13.06
1985	62.42	20.82	16.76
1990	60.10	21.40	18.50
1995	52.20	23.00	24.80
2000	50.00	22.50	27.50
2005	44.80	23.80	31.40
2010	36.70	28.70	34.60
2014	29.50	29.90	40.60

Data Source: International Labour Organization (2017).

⁵ According to some studies, the agricultural TFP growth was also relatively high throughout the 1990s and the first half of the 2000s (see, e.g., Wang et al., 2013).

7. *Sectoral employment shares*: There have been significant changes in the sectoral employment structure: in 1978 the agricultural sector dominated the Chinese economy regarding its employment share, as more than 70 percent of the population was engaged in farming activities. However, since the beginning of the reforms, there has been a gradual reallocation of employment from agriculture to manufacturing and services (see Table 1).
8. *Arable land*: A sequence of arable land increases occurred over the period 1982–1985. In particular, arable land (as a percentage of the land area) increased by more than 24 percent during this period (World Bank, 2017, own calculations).
9. *Exports and imports*: Chinese exports as well as imports have increased gradually since the beginning of the reforms.⁶ Analogously, as depicted by Figure 2, there has been a gradually increasing share of exports in the GDP since 1978.⁷

Figure 2 Export share in the GDP in China.



Data Source: World Bank (2017).

⁶ Between 1981 and 1984, the average annual exports (imports) grew at an average rate of 10.02% (9.16%), increasing to an average growth rate of 15.75% (14.44%) between 1985 and 1991 and then even further to 17.60% (17.59%) between 1992 and 2013 (NBS, own calculations). Prior to the reforms, China engaged in trade only on a very limited scale.

⁷ The declining tendency in recent years is due to the global financial crisis, leading to a decline in the global demand.

Table 2 Sectoral shares of exports and imports (as percentages).

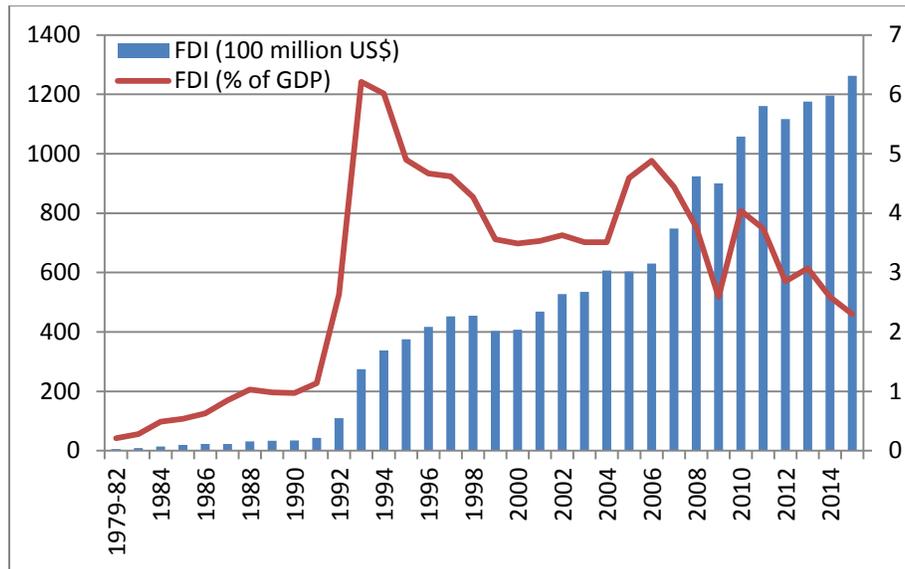
	Primary imports	Manufacturing imports	Primary exports	Manufacturing exports
1980	34.77	65.23	50.30	49.70
1985	12.52	87.48	50.56	49.44
1990	18.47	81.53	25.59	74.41
1995	18.49	81.51	14.44	85.56
2000	20.76	79.24	10.22	89.78
2005	22.38	77.62	6.44	93.56
2010	31.07	68.93	5.18	94.82
2013	33.75	66.25	4.86	95.14

Data Source: NBS.

10. *Export and import structure:* China's export structure has changed significantly since 1978: in 1978 the shares of manufacturing and agriculture in exports were approximately equal; then, especially since the mid-1980s, the export structure gradually shifted away from agriculture and towards manufacturing. During the same period, there has been a growing share of agricultural imports and a declining share of manufacturing imports (see Table 2).
11. *Foreign direct investment (FDI):* With respect to its amount and share in the GDP, FDI has become particularly important since the beginning of the 1990s (see Figure 3). After an initial jump in 1992/93, the FDI inflows increased, especially after China's WTO accession in 2001.⁸

⁸ Even after the global financial crisis, FDI grew at an average annual rate of 7.1% between 2008 and 2015.

Figure 3 Foreign direct investment in China.



Data Source: FDI (US\$100 million): NBS, Lardy (1995) for the years 1979–1982. FDI (percentage of GDP): World Bank (2017).

2.2 Economic reforms since 1978

The third plenum of the 11th Central Committee between 18 and 22 December 1978 marked not only the assumption of power by Deng Xiaoping but also the beginning of China’s reform era under the general policy of ‘reform and opening up’ (Naughton, 1995; Bramall, 2000; Zhu, 2012). The Chinese reforms have followed a rather gradual/incremental and evolutionary as well as an experimental approach (Rawski, 1994; Prasad and Rajan, 2006), which is often described as a ‘process of trial and error’ (or – in a more literally way – as ‘crossing the river by feeling for the stones’ (*mo shitou guohe*); see Lin, 1995; Naughton, 1995). Most research identifies three reform phases (for example Zheng et al., 2009; Zhu, 2012); other studies distinguish between two extended periods (Kanbur and Zhang, 2005; Brandt et al., 2014) or integrate smaller phases (Lin, 1995). We adopt the three-phase approach. The most important reforms and their main impacts on China’s economic development during the three reform phases are summarized in the following:

First phase of reforms (1978–1984): The reforms during the first phase targeted the agricultural sector and encompassed three policy measures: 1) an increase in agricultural goods’ prices around 1979 (Lin, 1992, 1995); 2) the household responsibility system (HRS) reform over the period 1981–1984, which increased the productivity in the agricultural sector (Lin, 1992; McMillan et al., 2000)⁹; and 3) an increase in arable land over the period 1982–1985 (see also Section 2.1). For various reasons the Chinese Government’s decision to first reform the agricultural sector made sense. First, the majority of the population lived in rural areas (Yao 1999) – around 82 percent in 1978 (NBS, own calculations). Second, China intended to ensure food security, in particular after the food crisis before 1978 (Zhu, 2012; Brandt et al., 2014). Third, among all three sectors, the agricultural sector was least centralized (Yao, 1999); therefore, reforms in that sector would not have been regarded as affecting the Chinese socialist orientation (as long as they did not involve changes in the state sector); see Guo (2013). As a result of the reforms, the agricultural output increased sharply (Lin, 1992; McMillan et al., 2000; Zheng et al., 2009; Zhu, 2012). However, there was a trend reversal around 1984, when the agricultural growth declined (Lin, 1992) and the agricultural TFP growth slowed down (Zheng et al., 2009; see also Section 2.1). One major reason for this development can be attributed to the fact that the HRS reform was completed in 1984 when 99 percent of production teams had adopted the HRS (Lin, 1992).

Second phase of reforms (1985–1992): During the second phase of reforms, a dual-track system was established (in the manufacturing sector) and the Government created a favorable policy environment for the so-called ‘township and village enterprises’ (TVEs; see Lin, 1995; Perotti et al., 1998; Lin and Yao, 1999; Zhu and Elbern, 2002).¹⁰ The latter gained quickly in importance (measured as their contribution to the GDP; see Table 3). The TVEs were characterized by relatively high productivity in comparison with state-owned enterprises (due to better incentive structures in these enterprises) (Jefferson and Rawski, 1994; Weitzman and Xu, 1994; Xu, 2011).

⁹ In particular, the HRS reform enhanced the incentives of households’ efforts to work more efficiently (Zhu, 2012). Under the former production team system, the incentives to work were very small, as it was difficult to monitor the individual efforts in a team (Lin, 1988). As a consequence of the HRS reform, state-owned land was assigned to peasants with contracts over a term of 15 years (Lin, 1992). After the households had fulfilled the state quota of grains at official prices, it was left to them to sell any extra grain at market prices (Zhu, 2012; Cao and Birchenall, 2013).

¹⁰ Besides the proactive and supportive role of the state since 1984, the positive spillover effects of the agricultural reforms (e.g. the rural labor surplus due to productivity increases and the rising demand for consumption goods and the possibility of capital accumulation due to the higher farmers’ per capita income) supported the take-off of the TVEs (see Jefferson and Rawski, 1994; Lin, 1995; Hu and Khan, 1997; Zhu and Elbern, 2002; Heytens and Zebregs, 2003).

Overall, the reforms of the second phase primarily dealt with (gradually) increasing the productivity of the manufacturing sector.

Third phase of reforms (1992–present): Deng Xiaoping’s southern tour in 1992 and his commitment to the open-door policy, which gave a decisive push to the renewed liberalization reform momentum, marked the beginning of the third reform phase (Brandt et al., 2014). Accordingly, the third phase reforms primarily dealt with the fostering of FDI and the further liberalization of trade. Although liberalization reforms had already taken place during the first two reform phases,¹¹ these reforms were restricted to the coastal area, and it was not until 1992 that China followed a more nationwide implementation of FDI-enhancing policies (by opening the inland region to FDI and by extending the preferential policies to inland cities). Furthermore, in anticipation of China’s WTO accession in 2001, the Chinese Government lowered its tariffs, reduced its restrictions on trade in services and strengthened its intellectual property rights, thus creating a more favorable business environment for foreign investors (Chen, 2011).

Table 3 Township and village enterprises.

	GDP of TVEs (percentage of total GDP)	Industrial output value of TVEs (percentage of na- tional output)
1978	3.64	9.1
1983	4.59	11.5
1984	6.41	16.3
1985	8.14	19.0
1986	9.27	21.8
1987	10.63	24.7
1988	11.62	27.4
1989	14.46	27.9
1990	28.58	29.7
1991	29.91	32.7

¹¹ Between 1978 and 1991, the first opening-up policies and laws were passed: in 1979, the Communist Party of China adopted the ‘Law of the People’s Republic of China on Sino-Foreign Equity Joint Venture Enterprises’ (Chen et al., 1995) and introduced a ‘foreign exchange retention system’ that allowed foreign enterprises to retain a small amount of foreign exchange (Chen et al., 1995; Chan and Tracy, 1999). In the following year, four special economic zones providing preferential tax treatment to foreign investors were established (Lin, 1995; Chan and Tracey, 1999), followed by 14 coastal cities in 1984, the development triangle in 1985 and finally the entire coastal area in 1988 (Chen, 2011).

1992	34.30	38.1
1993	22.05	48.7
1994	23.73	49.4
1995	23.88	55.8
1996	24.67	56.1
1997	26.11	57.9

Data Source: The GDP of TVEs (percentage of the total GDP): own calculations (data on the GDP of TVEs from Zuo (2009) and data on the total GDP from the World Bank (2017). Industrial output value TVEs (percentage of the national output): Lin and Yao (1999) and Zhu and El-bern (2002).

3 A neoclassical multi-sector growth model of the Chinese economy over the reform phases

The model is based on the modern multi-sector modeling literature and in particular on Laitner (2000), Kongsamut et al. (2001), Ngai and Pissarides (2007) and Acemoglu and Guerrieri (2008). This neoclassically spirited model shows that the Chinese growth process since 1978 can be understood as a sequence of transitory growth phases induced by the three reform phases. Thus, it implies that China's growth rate will decline significantly (and thus China will enter an MIT) unless there are further reforms that generate growth (primarily in the service sector).

3.1 Assumptions

3.1.1 Household preference structure

Although, particularly in the first phases of the reforms, China was not a free market economy and thus we cannot assume that the observed consumption patterns in the 1970s and 1980s were governed by the demand dynamics of Chinese households (rather, the Chinese Government commanded the consumption structure in the early phases of the reforms), it makes sense to model the Chinese household preferences for two reasons:

1) It can be assumed that the Chinese Government did not set the consumption structure arbitrarily but that, at least to some extent, the commanded consumption structure reflected (some) preference characteristics of the representative household (for example the fact that agricultural goods are needed to cover subsistence needs).

2.) Since 1978 the consumption structure has become increasingly determined by household preferences (and less by government commands) due to the increasing liberalization of the Chinese economy and its transformation into a (socialist) market economy.

Thus, we need a model of the preference structure of the Chinese population. We assume the preference structure suggested by Kongsamut et al. (2001). It is consistent with the major theories and empirical observations of the (qualitative) long-run consumption structure dynamics in developed and developing economies. The lifetime utility (U) of the representative (Chinese) household is a standard constant intertemporal elasticity of substitution function of the consump-

tion index ($C(t)$), where ρ is the time preference rate, θ is the intertemporal elasticity of substitution and t is the time index.

$$(1) \quad U = \int_0^{\infty} \frac{C(t)^{1-\theta}-1}{1-\theta} e^{-\rho t} dt \quad \theta > 0 \quad \rho > 0$$

Following Kongsamut et al. (2001), we assume that the consumption index is a Stone–Geary function, where C_1 , C_2 and C_3 represent the consumption of agricultural, manufacturing and service goods, respectively.

$$(2) \quad C(t) = \prod_{i=1}^3 (C_i(t) - \bar{C}_i)^{\sigma_i}$$

$$(3) \quad \sum_{i=1}^3 \sigma_i = 1$$

The parameters \bar{C}_i represent the subsistence levels, where we follow Kongsamut et al. (2001) and assume that the household has positive subsistence needs regarding agricultural goods and some endowments with respect to services, that is

$$(4) \quad \bar{C}_1 > 0, \bar{C}_2 \approx 0^+, \bar{C}_3 < 0$$

We assume that the representative household seeks to maximize the lifetime utility (1)–(4) subject to the following dynamic constraint:

$$(5) \quad \dot{W}(t) = x(t)W(t) + w(t)N(t) - \sum_{i=1}^3 p_i(t)C_i(t)$$

where W is the wealth of the representative household, x is the rate of return on wealth, w is the wage rate, N is the labor supply of the household and p_i is the price of good i . The solution to this intertemporal maximization problem is derived in Appendix 1 and yields the following equations:

$$(6a) \quad \frac{\dot{\tilde{E}}(t)}{\tilde{E}(t)} = \frac{x(t)-\rho}{\theta} + \frac{1-\theta}{\theta} \frac{\dot{p}(t)}{p(t)}$$

$$(6b) \quad \forall i \in \{1,2,3\} \quad C_i(t) = \tilde{E}(t) \frac{\sigma_i}{p_i(t)} + \bar{C}_i$$

where

$$(7) \quad \tilde{E}(t) := E(t) - \bar{C}(t)$$

$$(8) \quad E(t) := \sum_{i=1}^3 p_i(t)C_i(t)$$

$$(9) \quad \bar{C}(t) := \sum_{i=1}^3 p_i(t) \bar{C}_i$$

$$(10) \quad p(t) := \prod_{i=1}^3 \left(\frac{\sigma_i}{p_i(t)} \right)^{\sigma_i}$$

The variables in (6)–(10) can be interpreted as follows (see Stijepic and Wagner, 2015): \tilde{E} is the “excess consumption,” E denotes the aggregate consumption expenditures, \bar{C} is the current value of net subsistence needs and p is the aggregate price index (Cobb–Douglas index).

Given standard parameterization (see Kongsamut et al., 2001; Stijepic, 2010; Herrendorf et al., 2014), where among others the subsistence levels are covered, (6)–(10) imply the following characteristics of the household demand system:

1. Given constant prices (p_i), if wealth increases (or if consumption expenditures increase), the consumption share of agriculture $p_1 C_1/E$ decreases, the consumption share of manufacturing $p_2 C_2/E$ increases (slightly) and the consumption share of services $p_3 C_3/E$ increases.
2. An (exogenous) increase in the price p_i of good i reduces the demand (C_i) for good i .

3.1.2 Production structure, factor accumulation and GDP

We assume that the output of agriculture (Y_1), manufacturing (Y_2) and services (Y_3) is generated via Cobb–Douglas production functions:

$$(11) \quad Y_1(t) = A_1(t)[n_1(t)N(t)]^{\alpha_N^1}[k_1(t)K(t)]^{\alpha_K^1}[L(t)]^{\alpha_L^1} \quad \alpha_N^1 + \alpha_K^1 + \alpha_L^1 = 1$$

$$(12) \quad Y_2(t) = A_2(t)[n_2(t)N(t)]^{\alpha_N^2}[k_2(t)K(t)]^{\alpha_K^2}[R(t)]^{\alpha_R^2} \quad \alpha_N^2 + \alpha_K^2 + \alpha_R^2 = 1$$

$$(13) \quad Y_3(t) = A_3(t)[n_3(t)N(t)]^{\alpha_N^3}[k_3(t)K(t)]^{\alpha_K^3} \quad \alpha_N^3 + \alpha_K^3 = 1$$

where A_i is the productivity index of sector i , n_i (k_i) represents the share of employment (capital) devoted to sector i , N is the aggregate employment, K is the aggregate capital, L stands for the input of land (in agricultural production) and R is the input of agricultural intermediates/resources (for example steel and coal) in manufacturing. As we can see, all three sectors use capital and labor as inputs; the output elasticities of input capital (labor) differ across sectors (see Acemoglu and Guerrieri, 2008). Moreover, land is employed only in the agricultural sector (see Laitner,

2000); only the manufacturing sector employs agricultural intermediates. These assumptions are generally standard in multi-sector modeling.

The agricultural resources (R) used in the manufacturing sector as intermediates are extracted in the agricultural sector. Moreover, the agricultural sector produces agricultural consumption goods (C_1). Thus,

$$(14a) \quad C_1(t) + R(t) = Y_1(t)$$

We define the auxiliary variable:

$$(14b) \quad s_1 := R/Y_1$$

s_1 indicates the share of agricultural production used as intermediates in industrial production.

Capital goods (K), for example machines, are produced in the manufacturing sector. Furthermore, manufactured goods are consumed (C_2):

$$(15a) \quad \dot{K}(t) + \delta K(t) + C_2(t) = Y_2(t)$$

We define the savings rate as follows:

$$(15b) \quad s_2 := 1 - C_2/Y_2$$

s_2 is the share of industrial production used for capital investment.

Services are consumed only:

$$(16) \quad C_3(t) = Y_3(t)$$

The aggregate labor (N) grows at an exogenous rate.

$$(17) \quad \dot{N}(t)/N(t) = \gamma_N$$

We omit (endogenous) human capital accumulation, since it was relatively slow and contributed little to the GDP growth over the reform period in China (see Section 2.1). Moreover, in general human capital accumulation plays an inferior role in growth at earlier stages of development.

We do not discuss the effects of unemployment or disuse of capital. Thus, we assume that all labor (L) and capital (K) are used in production, that is

$$(18) \quad \forall t \quad \sum_{i=1}^3 n_i(t) = 1, \sum_{i=1}^3 k_i(t) = 1$$

We define the aggregate output (GDP) as follows:

$$(19) \quad Y(t) = \sum_{i=1}^3 p_i(t) Y_i(t)$$

3.2 Growth phases

Let $t = 1978$ indicate the initial state of the Chinese economy in our model that is the starting point of the reforms in China. The period $t \in (1978, 1984)$ covers the first phase of the reforms, the period $t \in (1985, 1991)$ covers the second phase of the reforms and the period $t \in (1992, 2016)$ covers the third phase of the reforms.

3.2.1 Growth over the first and second reform phases

First, we discuss the parameterization of the model. Then, we consider the potential growth sources and policies given this parameterization. We briefly discuss the optimal sequence of the reforms using the arguments derived from our model and the theoretical literature, implying that the Chinese Government has chosen the optimal sequencing of the reforms since 1978. The latter discussion is structured as follows: first, we determine which of our model parameters were affected by the reforms, specifically deriving the sequences of the parameter changes induced by the reforms; then, we discuss the model dynamics under these parameter change sequences.

3.2.1.1 Parameterization of the model for the first and second phases

Let the following variables denote the (initial) levels of technology, land, population and capital in 1978:

$$(20) \quad A_i(1978) = \bar{A}_i^0, L(1978) = \bar{L}_0, N(1978) = \bar{N}_0, K(1978) = \bar{K}_0$$

As shown in Section 2.1, the Chinese population growth rate over the reform period was around 1 percent per year. Since the effects of population growth in neoclassical growth models are well-known and straight-forward, we abstract from population growth to simplify the equations, that is we assume:

$$(21) \quad \gamma_N = 0 \leftrightarrow N(t) = \bar{N}_0 \text{ for } t > 1978$$

As we will see in Section 3.2.1.2, our model of the first and second phases is characterized by a steady-state capital value K^* , and capital is accumulated as long as the capital level is below its steady-state value. As discussed in Section 2.1, around 1978 China had a positive capital accumulation rate (and capital accumulation was a major contributor to the GDP growth), that is $\dot{K}(1978) > 0$. Thus, we must assume that the initial capital level (in 1978) was below its steady-state value (K^*):

$$(22) \quad K(1978) < K^* \leftrightarrow \dot{K}(1978) > 0$$

China was a planned/command economy in 1978. Although the Government pursued a gradual decentralization/liberalization program over the three reform phases, we assume for reasons of simplicity that China was a (completely) planned economy during the first two reform phases and a decentralized (market) economy during the third phase. (In Section 3.2.1.6 we discuss the effects of gradual liberalization/decentralization separately.) There are different alternatives for a command economy (for example the planning authorities may determine the inputs or the outputs). Since we neglect planning errors and missing incentives (except in Section 3.2.1.6), it does not matter for the results of our model which of these alternatives is chosen. For simplicity we assume that the planning authority determines (at least implicitly) the savings rates (s_1 and s_2), the factor allocation (among others the sectoral employment and capital shares) and the prices given the productivity levels and the sectoral production functions. Thus, in our model the following variables are exogenous (that is not determined by the market) in 1978 and over the first two phases of the reforms:

$$(23) \quad s_1(t) = \bar{s}_1, s_2(t) = \bar{s}_2, n_i(t) = \bar{n}_i, k_i(t) = \bar{k}_i, p_i(t) = \bar{p}_i \quad \text{for } 1978 \leq t \leq 1991$$

As implied by the empirical evidence (cf. Section 2), China was a relatively little developed command economy in 1978 and the productivity growth over the first two reform phases was generated primarily by the reforms. (The evidence shows that TFP was constant or even decreasing before 1978.) Thus, we abstract from any endogenous TFP growth (for example R&D-induced technological progress) and assume that innovation and productivity improvements were exclusively caused by the reforms and thus the productivity parameters are exogenous:

$$(24) \quad A_i(t) = \bar{A}_i \quad \text{for } i = 1, 2, 3$$

This is consistent with the evidence stating that TFP was constant (or even decreasing) before 1978.

We will later discuss and explain the detailed pattern along which the exogenous productivity parameters changed and replace (24) by a sequence of productivity parameter changes.

This is true analogously for arable land. The evidence implies that it has changed primarily due to the reforms. Thus, we assume that it is exogenous and will later specify its exact pattern of (reform-induced) changes:

$$(25) \quad L(t) = \bar{L}$$

Although the parameterization (20)–(23) implies that the consumption structure is not determined by the household preferences and thus does not (necessarily) follow (6), we assume nevertheless that the planning authority tries to satisfy (some aspects of) the household preferences to some extent. In particular, we assume that in 1978 the planning authorities choose the factor allocation such that the subsistence needs are covered (see the evidence in Section 2.2), that is

$$(26) \quad C_1(t) > \bar{C}_1 \text{ for } t \geq 1978$$

Under these assumptions (and in particular under the assumption of a planned economy described above), the Chinese Government has several policy alternatives for creating growth, which we discuss now.

3.2.1.2 Growth sources and policies creating (transitory) growth over the first and second phases

In this section we discuss the (transitory) growth-generating policies implied by our model.

Henceforth, we omit the time indexes to simplify the notation.

Under the assumptions made in Sections 3.1 and 3.2.1.1, we can derive the following equations for the per capita GDP ($y \equiv Y/\bar{N}$) and capital intensity ($k \equiv K/\bar{N}$):

$$(27) \quad y = \bar{p}_1 \bar{A}_1 \bar{f}_1 k^{\alpha_k^1} \bar{l}^{\alpha_L} + \bar{p}_2 \bar{A}_2 \bar{f}_2 k^{\alpha_k^2} (\bar{s}_1 \bar{A}_1 \bar{f}_1 k^{\alpha_k^1} \bar{l}^{\alpha_L})^{\alpha_R} + \bar{p}_3 \bar{A}_3 \bar{f}_3 k^{\alpha_k^3}$$

$$(28) \quad \frac{\dot{k}}{k} = \bar{s}_2 k^{\alpha_k^2 + \alpha_k^1 \alpha_R - 1} \bar{A}_2 \bar{f}_2 (\bar{A}_1 \bar{f}_1)^{\alpha_R} \bar{s}_1^{\alpha_R} \bar{l}^{\alpha_L \alpha_R} - \delta - \gamma_N$$

where

$$(29) \quad \bar{f}_i = \bar{n}_i^{\alpha_N} \bar{k}_i^{\alpha_K}$$

indicate the cross-sector allocation of factors (capital and labor) for $i = 1, 2, 3$; $\bar{l} \equiv \bar{L}/\bar{N}$ is the land intensity, which is constant due to (21) and (25).

Note that, to derive (27) and (28), we do not use the optimal consumption structure (6) nor the standard optimality conditions for cross-sector factor allocation, since China was a planned economy in the first phases of the reforms and it does not make sense to assume that the planning authorities (succeeded in) set(ting) the production structure and the prices according to the optimal household demand structure and the associated optimal cross-sector factor allocation.

Equation (27) implies that in 1978 the Chinese planning authorities had the following options for generating (transitory) GDP growth.

Growth Source/Policy 1. Changes in cross-sector factor allocation ($\bar{f}_1, \bar{f}_2, \bar{f}_3$)

Changes in the sectoral employment shares (\bar{n}_i) and capital shares (\bar{k}_i) have impacts on \bar{f}_1, \bar{f}_2 and \bar{f}_3 and thus on the aggregate per capita GDP (y) (cf. (27) and (29)).

a) As implied by (27), if the employment share (\bar{n}_i) of the sectors (i) that have relatively high (value of) labor productivity ($\bar{p}_i y_i / \bar{n}_i$) is increased, the aggregate per capita output (y) increases, ceteris paribus. An analogous statement can be made for the capital share \bar{k}_i . This aspect has been studied by Baumol (1967) and Ngai and Pissarides (2007). Note that this policy option seems not to be preferable for 1978 China for several reasons. First, the withdrawal of factors from the agricultural sector (and employment in the manufacturing or service sector) may endanger the satisfaction of subsistence needs regarding agricultural goods (cf. (1)–(4)) in the light of the low productivity of the agricultural sector (see the evidence in Section 2.1) and the susceptibility of planned economies to food crises. See also Section 3.2.1.3. Second, the withdrawal of production factors from the manufacturing sector may have a negative dynamic effect on capital accumulation and per capita GDP (y) growth, as discussed below (cf. Policy 5). Third, the withdrawal of production factors from the service sector seems to contradict the long-run preferences

of the representative household, which demands more services with increasing income (see also Section 3.1.1).

b) Since the output elasticity of capital (output elasticity of labor) differs across sectors, as indicated by cross-sector differences in α_K^i (α_N^i), a change in the sectoral capital intensities $\bar{k}_i K / (\bar{n}_i \bar{N})$ can lead to an increase in the aggregate output (y), ceteris paribus. In particular, a change in the sectoral employment and capital shares (\bar{n}_i and \bar{k}_i) can have a positive impact on y if labor is substituted by capital in sectors that are characterized by relatively high output elasticity of capital, while capital is substituted by labor in sectors that have relatively low output elasticity of labor (see also Acemoglu and Guerrieri, 2008). This is implied almost directly by (27) and (29). Overall, Policy 1b seems to be an adequate policy for 1978 China.

Note, however, that the growth effects of Policy 1 are limited. First, the employment and capital shares (\bar{n}_i and \bar{k}_i) are limited by 0 and 1. Thus, if labor and capital are reallocated to some sector(s), after some time all capital and labor have been reallocated to this sector and there is no scope for further reallocation to this sector. Moreover, since agricultural output is required for the satisfaction of subsistence needs (cf. (1)–(4) and (14a)) and as an (essential) intermediate (cf. (12) and (14a)) and manufacturing output is required as an essential production factor (capital) in all sectors (cf. (11)–(13) and (15a)), not all capital and labor employed in agriculture and manufacturing can be withdrawn from agriculture and manufacturing, ceteris paribus. Overall, by pursuing Policy 1, only transitory growth of y can be generated, since there are limits to factor reallocation.

Growth Source/Policy 2. Increases in arable land (\bar{L})

Equation (27) implies that an increase in arable land (\bar{L}) is associated with an increase in aggregate per capita output (y), ceteris paribus. Since the amount of arable land is limited by the natural restrictions and (political) borders of the country, it is obvious that only transitory growth can be generated by pursuing Policy 2. Nevertheless, Policy 2 seems in general to be adequate for 1978 China, since among others it helps to ensure the subsistence needs; as we will see, China pursued this policy.

Growth Source/Policy 3. Increases in the share (\bar{s}_1) of agricultural intermediates.

As implied by (27), an increase in \bar{s}_1 leads to an increase in y , ceteris paribus. Since \bar{s}_1 cannot be greater than 1, the y -growth generated by Policy 3 is limited, that is Policy 3 can generate only transitional growth. Moreover, since agricultural output is required for satisfaction of subsistence needs (cf. (1)–(4) and (14a)), \bar{s}_1 must be even smaller than 1. Thus, the potential for growth creation by increasing \bar{s}_1 is even more limited. The key disadvantage of Policy 3 is that the withdrawal of input factors from food production (C_1) (and their employment in resource (R) production) may endanger the satisfaction of subsistence needs regarding agricultural goods (cf. (1)–(4)) in the light of the low productivity of the agricultural sector and the susceptibility of planned economies to food crises.

Growth Source/Policy 4. Changes in prices (\bar{p}_i)

Obviously, an increase in (government-set) prices (\bar{p}_i) increases the per capita GDP (y), ceteris paribus (cf. (27)). However, this is only a nominal increase; it is always possible to increase the per capita GDP by increasing the prices by decree, which has nothing to do with real economic growth. If the change in prices affects relative prices (\bar{p}_i/\bar{p}_j), that is not all prices are raised by the same percentage, it has effects on the welfare of the representative household, as implied by (1), (2) and (5). However, in this paper we are interested not in welfare but in GDP growth; thus, we do not discuss this effect in detail.

Growth Source/Policy 5. Capital accumulation (\dot{K})

An increase in capital (K) is associated with an increase in capital intensity (k), ceteris paribus. Equation (27) implies that an increase in capital intensity is associated with an increase in per capita GDP (y). Thus, growing capital intensity is associated with a growing per capita GDP.

Equation (28) implies that capital intensity converges to a stable steady state (k^*), which is determined as follows:

$$(30) \quad \frac{\dot{k}}{k} = 0 \leftrightarrow k^* = (1/\delta \bar{s}_2 \bar{A}_2 \bar{f}_2 (\bar{A}_1 \bar{f}_1)^{\alpha_R} \bar{s}_1^{\alpha_R} \bar{l}^{\alpha_L \alpha_R})^{1/(1-\alpha_k^2 - \alpha_k^1 \alpha_R)}$$

If the initial capital level (k_0) is smaller than the steady-state level (k^*), the capital intensity grows and converges to the steady-state value (k^*), that is there is transitory growth in capital intensity. As implied by (28), the growth rate of capital intensity declines over the convergence process to the steady state, since capital has decreasing returns in capital production ($\alpha_K^2 + \alpha_K^1 \alpha_R < 1$). (The proof of these facts is analogous to the corresponding proof in the Solow–Swan growth model.) Thus, the per capita GDP growth generated by capital accumulation is transitory (cf. (27)).

Equation (30) implies that transitory capital intensity growth can be generated by the following policies:

a) Policy 1a and, in particular, an increase in capital or the employment share of the manufacturing or agricultural sector (that is reallocation of labor or capital from the service sector to the agricultural or manufacturing sector). This, policy seems, however, to contradict the long-run preferences of the representative household, which seeks to increase the service share with increasing income (see Section 3.1.1).

b) Policy 1b and in particular labor–capital substitution according to the sectoral output elasticities, for example the reallocation of labor and capital between agriculture and manufacturing such that the capital intensities in these two sectors become optimal. This policy seems to make sense and has been pursued by the Chinese Government during the reforms, as we will see later.

c) Policy 2 (increase in \bar{L}). This policy makes sense and has been pursued by the Chinese Government during the reform phases.

d) Policy 3 (increase in \bar{s}_1). This policy seems to be risky in the light of the low productivity of the agricultural sector and the food production crises, since it reduces the resources used for food production (and thus reduces the consumption closer to the subsistence level). See also Section 3.2.1.3.

e) Increase in the savings rate (\bar{s}_2). This policy seems to be risky for the same reasons (cf. the discussion of Policy 3).

f) Increase in the manufacturing sector TFP (\bar{A}_2).

g) Increase in the agricultural sector TFP (\bar{A}_1).

As discussed above, Policies 1 to 3 are limited to some extent, and thus only limited increases in capital intensity, that is only transitory capital intensity growth, can be generated by them. The savings rate (\bar{s}_2) cannot be increased beyond 1. Thus, increases in the savings rate can only generate transitional dynamics of the capital intensity. The only way to generate permanent growth of capital intensity is by steadily increasing the TFP in the agricultural or manufacturing sector. This aspect will be discussed in detail later.

Overall, capital accumulation is transitory in our model (unless a program of capital accumulation-generating policies a)–g) is induced). Thus, the growth impulses generated by capital accumulation can generate only transitory growth of the per capita GDP (unless a program of policies a)–g) is induced).

Growth Source/Policy 6. Increases in TFP (\bar{A}_i)

Equation (27) implies that an increase in one of the sectoral productivity parameters \bar{A}_1 , \bar{A}_2 or \bar{A}_3 is associated with an increase in the per capita GDP (y), ceteris paribus. Equation (28) implies that only an increase in the productivity rates of the agricultural and manufacturing sectors (\bar{A}_1 and \bar{A}_2) has direct effects on capital accumulation. At least theoretically, and this has been shown by models of endogenous growth (for example learning-by-doing models and R&D models), productivity parameters can grow without limits. Thus, in contrast to Policies 1–5, Policy 6 seems to be the only way to generate non-transitory (long-run) growth, provided that the government/economy succeeds in creating an infinite sequence of \bar{A}_i increases.

Summary of the growth policy options

While the above discussion of Policies 1–6 focused on the direct effects of the reforms, note that there are also secondary effects of the reforms. This fact has been demonstrated in the discussion of Policy 5: Policies 1–3 have not only a direct effect on y but also an impact on capital accumulation and via capital accumulation an indirect effect on y , since capital accumulation generates y growth. At least in a decentralized economy, which will be relevant to the discussion of the phase-three reforms, there are several other indirect effects that we do not investigate here (since they are not relevant to the discussion of the first- and second-phase reforms); for example, Poli-

cy 6 can have an impact on factor allocation (cf. Policy 1). We will discuss these indirect effects as they arise in Section 3.2.1.5.

Overall, our model implies that Policies 1b, 2 and 6 are adequate for generating growth in 1978 China. However, in the spirit of neoclassical growth theory, our model implies that long-run growth can be generated only by policies that generate an infinite sequence of increases in the sectoral technology parameters \bar{A}_i (Policy 6). In general these policies affect different sectors. Thus, at this point the question arises of which of the sectors (for example which of the technology parameters \bar{A}_1 , \bar{A}_2 and \bar{A}_3) should be reformed (raised) first (unless all the parameters can be raised at the same time).¹² We will discuss this question now.

3.2.1.3 The optimal sequence of the reforms

As shown in Section 3.2.1.2, long-run growth can be generated in our model only by stimulating the TFPs (that is the \bar{A}_i) of the sectors by reforming the sectors. (Moreover, Policies 1b and 2 seem to be adequate for generating transitory growth in 1978 China.) Since in general a simultaneous reform of all sectors seems not to be advisable for many reasons (see Footnote 12), the question arises of which of the sectors should be reformed first, second and third, that is the question of the optimal sequencing of the sectoral reforms. Our model provides arguments that the optimal reform sequence is first the agricultural sector, then the manufacturing sector and finally the service sector, as discussed in the following.

First, we turn to the question of whether the service sector reforms should precede the agricultural and manufacturing reforms. In general our model and the economic theory imply that the agricultural and manufacturing reforms should precede the service sector reforms for the following reasons. First, the evidence and in particular the experience of the developed countries imply that productivity increases in the service sector are difficult to achieve, since services usually require personal interactions between humans or even face-to-face contact such that the extent of labor–capital substitution is limited; see for example Baumol (1967), Blinder (2005, 2007) and Wagner

¹² There is an extensive literature discussing whether (productivity-enhancing) market reforms should be implemented via a big push (affecting all sectors) or whether they should be conducted in small steps (targeting one sector after another). See Wagner (1997) for a discussion. For example, the resources needed for the reforms may be limited. Thus, only one sector after another may be reformed. Moreover, a big push may overburden the economy and the population. Furthermore, the optimal sequence of the reforms regarding the stability of the economy may be chosen.

(2013). Second, the service sector makes a relatively small contribution to the GDP in less developed countries (like China in 1978). Thus, the improvement in productivity in this sector contributes less to the aggregate GDP than the improvement in productivity in the other, larger sectors. Third, equation (28) implies that an increase in \bar{A}_3 does not boost capital accumulation directly; thus, its growth effects are not accompanied by the (transitory) growth effects of accompanying capital accumulation. In contrast an increase in \bar{A}_1 and \bar{A}_2 has a direct effect on capital accumulation (cf. (28)) and is thus accompanied by transitory growth generated by capital accumulation. Therefore, it seems to make sense to focus reform resources on reforms of the agricultural and manufacturing sectors.

Now we turn to the question of the optimal sequence of agricultural and manufacturing reforms. Our model provides important arguments for reforming the agricultural sector first. Agricultural resources (R) are an essential input factor in manufacturing (cf. (12)) and thus are essential for the production of capital (K), which is an essential input factor in all sectors. Consequently, it makes sense to ensure the production of agricultural resources (R), since inefficiencies in it affect all sectors and hinder capital accumulation. More importantly, there is a subsistence level regarding agricultural goods (cf. (1)–(4)). It makes sense to improve the productivity of agriculture to ensure the coverage of subsistence needs. This aspect appears to be particularly relevant in the light of food production crises in many socialist/planned economies (for example the crises in the USSR and China) and low productivity in the agricultural sector (see Section 2.2 for evidence).

Overall, there are major (macro) arguments for reforming the agricultural sector first, then reforming the manufacturing sector and finally reforming the service sector, in the case of 1978 China. This was the Chinese Government's choice in its reform efforts, as will be explained now.

3.2.1.4 The effects of the phase 1 and phase 2 reforms on the model parameters

As discussed in Section 2.2, the *first-phase* reforms targeted the agricultural sector and encompassed three policy measures: 1) an increase in agricultural goods' prices (Policy 4) around 1979; 2) the HRS reforms over the period 1981–1984, which increased the productivity (A_1) in the agricultural sector (Policy 6); and 3) an increase in arable land (Policy 2) over the period 1982–1984. (Note that the increases in arable land occurred in 1985 as well. For modeling simplicity we assume that they occurred for the last time in 1984.)

These reforms can be expressed in terms of our model parameters as follows:

$$(31) \quad \bar{p}_1(t) = \bar{p}_1^1 \text{ for } 1978 \leq t < 1979, \bar{p}_1(t) = \bar{p}_1^2 \text{ for } 1979 \leq t < 1991, \bar{p}_1^1 < \bar{p}_1^2$$

$$(32) \quad \bar{A}_1(t) = \bar{A}_1^j \text{ for } t_{A1}^j < t \leq t_{A1}^{j+1}, j = 1, 2, 3, 4, 5, 6, 7, \dots, z-1;$$

$$1981 \leq t_{A1}^1 < t_{A1}^2 < \dots < t_{A1}^z = 1984; \bar{A}_1(1981) \leq \bar{A}_1^1 < \bar{A}_1^2 < \dots < \bar{A}_1^z$$

$$(33) \quad \bar{L}(t) = \bar{L}^j \text{ for } t_L^j < t \leq t_L^{j+1}, j = 1, 2, \dots, z-1; 1982 \leq t_L^1;^{13}$$

$$\bar{L}(1982) \leq \bar{L}^1 < \bar{L}^2 < \dots < \bar{L}^z; \bar{L}(t) = \bar{L}^z \text{ for } t \geq t_L^j$$

Note that (32) implies that there was TFP growth in the agricultural sector (due to HRS reforms) only during the first phase, that is there was a sequence of TFP increases (at the time points t_{A1}^j) over the period 1981–1984. That is, (32) states that the HRS reform's effect on the agricultural TFP was transitory. As discussed in Section 2.2, there is some evidence that supports this view. However, there is also evidence that states that the agricultural TFP growth was relatively high even over the second and third phases. The latter aspect can be modeled by assuming that the second- and third-phase reforms influenced the agricultural TFP (for example the second-phase reform increasing the capital intensity of the agricultural sector may have paved the way for capital-embodied technological progress). We will later discuss this way of modeling the agricultural TFP growth over the second and third phases.

Equation (33) states that there was a sequence of arable land increases (at time points t_L^j) over the period 1982–1984, which is consistent with the empirical evidence discussed in Section 2.1.

As shown in Section 2.2, during the *second phase* of reforms, the dual-track system was established (in the manufacturing sector) and TVEs became increasingly important. The latter quickly gained in importance (measured as their contribution to the GDP) and were characterized by relatively high productivity in comparison with public enterprises (due to better incentive structures in these enterprises). These reforms targeted primarily the manufacturing sector. Overall, the second-phase reforms dealt with (gradually) increasing the productivity (A_2) of the manufacturing sector (Policy 6). These facts can be expressed in terms of our model's parameters as follows:

¹³ Note that $t_L^1 > t_{A1}^1$.

$$(34) \quad \bar{A}_2(t) = \bar{A}_2^j \text{ for } t_{A_2}^j < t \leq t_{A_2}^{j+1}; j = 1, 2, \dots, z - 1; 1985 \leq t_{A_2}^1 < t_{A_2}^2 < \dots < t_{A_2}^z = 1991;$$

$$\bar{A}_2(1985) \leq \bar{A}_2^1 < \bar{A}_2^2 < \dots < \bar{A}_2^z$$

Equation (34) states that there was a sequence of TFP increases in the manufacturing sector (at the time points $t_{A_2}^j$) over the period 1985–1991. Figure 4a depicts the parameter changes (31)–(34).

Now we have fully parameterized our model for studying the dynamics of the economy and in particular the dynamics of the per capita GDP over the first and second phases of the reforms.

3.2.1.5 Dynamics of the model over the first and second phases

Given the parameterization introduced in Section 3.2.1.1 and the reform-induced parameter changes discussed in Section 3.2.1.4, we now derive the dynamics of the per capita GDP in our model.

According to (22), K is below its steady-state level ($K_0 < K^*$) in 1978; thus, capital is accumulated, that is the capital intensity is growing around 1978 (cf. (28) and (30)) and thus the aggregate per capita GDP (y) is growing (cf. (27) and Growth Source 5). However, due to the decreasing marginal productivity of capital, the capital accumulation rate decreases over time (cf. (28)) and thus the GDP growth rate decreases over time (cf. (27)) and converges to zero (see also the discussion of Growth Source 5). This growth decline is counteracted by the sequence of agricultural TFP (A_1) and arable land (L) increases during the *first phase*, that is between 1979 and 1984 (cf. (32) and (33)). Moreover, these increases have a secondary effect: they gradually increase the steady-state capital intensity over the period 1979–1984 (cf. (30), (32) and (33)) and thus generate transitory growth of capital intensity over this period (and beyond). This transitory growth of capital intensity is associated with the growth of the per capita GDP (cf. (27)).

These developments over the *first phase* have secondary effects on the economy. First, the fact that the per capita income (y) grows and capital is accumulated implies that, in general, there is a positive (implicit) rate of return (x) on the (implicit) household wealth (W). (Usually it is assumed in this type of model that wealth is invested in capital, that is $K = W$, and income (y) is equal to the asset income (xW) and labor income (wN .) Equation (6) implies that the representative household prefers growing consumption expenditures (E) if the rate of return (x) on wealth

(W) is sufficiently high (that is, exceeds the time preference rate). Moreover, as explained in Section 3.1.1, the representative household prefers to increase the expenditure shares of manufacturing and services as consumption expenditures grow (provided that the subsistence needs are covered). Overall, this discussion implies that, due to the growing income over the first phase, the household prefers a demand shift from agriculture to manufacturing and services. Second, this tendency is magnified by the increase in the price for agricultural goods in 1979 (cf. (31) and (6b)). Third, the aforementioned increase in the agricultural TFP (A_1), arable land (L) and capital (K) implies that, given the factor inputs, the output potential of the agricultural sector increases (cf. (11)). Overall, our model implies that the first-phase reforms had a negative impact on the agricultural demand (in favor of manufacturing and service demand) while increasing the output potential of the agricultural sector significantly; moreover, according to our model, the positive impacts of the reforms on capital accumulation created/backed the demand for manufactured goods, since capital goods are produced by the manufacturing sector (cf. (15a)). Thus, it is not surprising that the Chinese economy (or the planning authorities) reacted to this situation by gradually reallocating the production factors and in particular labor from the agricultural sector to the manufacturing sector (and the service sector) during the first phase (and beyond), as shown by the empirical evidence in Section 2.1. This reallocation generated (transitory) y growth (cf. Growth Source 1a).

Overall, the reforms of the first phase generate only transitory growth. That is, unless further reforms are implemented, the growth rate of the capital intensity and per capita GDP decline and converge to zero.

Not only for this reason, a reform of the manufacturing sector seems to be necessary at the end of the first reform phase. At the beginning of the second phase, the effects of the first-phase reforms were still present. In particular, the rate of capital accumulation was high (higher than in 1978) and the demand for manufactured consumption goods had increased. Both types of goods are produced by the manufacturing sector (cf. (15a)). Thus, a reform of the manufacturing sector seems to make sense to improve the productivity and satisfy the demand for manufactured goods (and ensure welfare and growth effects). The second-phase reform of the manufacturing sector induces a sequence of TFP increases (Policy 6) in the manufacturing sector (cf. (34)). These increases have not only a direct effect on the per capita GDP (cf. (27) and (34)) but also an indirect effect: they gradually increase the steady-state level of capital (cf. (30) and (34)) and thus gener-

ate (additional) transitional capital accumulation throughout the second phase and beyond (cf. (28) and (34)). This (transitory) capital accumulation produces additional (transitory) per capita GDP growth (cf. (27)). Since capital is used as an input factor in all sectors (cf. (11)–(13)), the productivity increases in the manufacturing sector have a positive impact on the production potential of all the sectors (that is it allows an increase in the capital intensity in these sectors), *ceteris paribus* (and in particular given a constant savings rate s_2). This helps to meet the additional demand in the service and manufacturing sectors (generated by the first-phase and second-phase reforms) and increases the potential of the agricultural sector to produce the resources (R) that are needed for manufacturing.

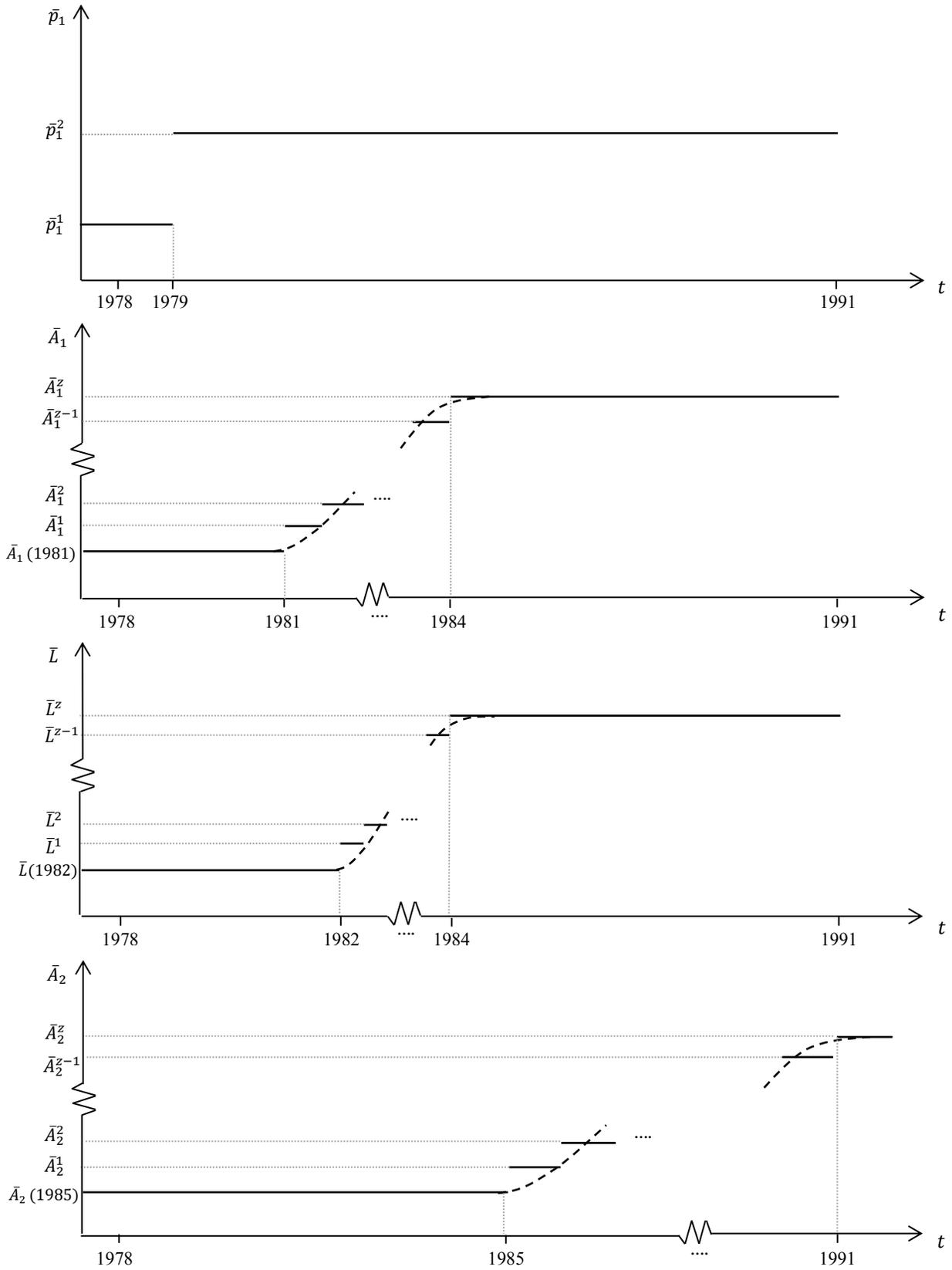
Note that the income increases generated by the second-phase reforms further shifts the household demand from agriculture to manufacturing and services. Thus, the second-phase reforms generate additional pressure for factor reallocation from agriculture to manufacturing and services in our model. (The proof of this fact is analogous to the corresponding proof in the context of the first-phase reforms.) However, since, at the same time, the manufacturing sector productivity and thus the output potential of the manufacturing sector increase (cf. (34), that is an effect is generated that pushes the labor force out of the manufacturing sector and counteracts the other effects), our model implies that a potentially stronger shift of production factors towards services is generated by the second-phase reforms than by the first-phase reforms. Moreover, the reallocation of employment from agriculture to manufacturing results in growth of y (cf. Growth Source 1a).

As noted in Section 3.2.1.4, due to the fact that the second-phase reforms increase the productivity of the manufacturing sector and thus allow capital to be produced more efficiently, thereby increasing the capital intensity in agriculture among others (which happens in the later stages of phase 2), additional potential for (capital-embodied) technological progress is generated in the agricultural sector. This fact could explain the growing productivity parameters (A_1) in the agricultural sector during the second phase and beyond. We omit, however, further modeling of this aspect, since the discussion would be similar to the discussion of the first-phase reforms.

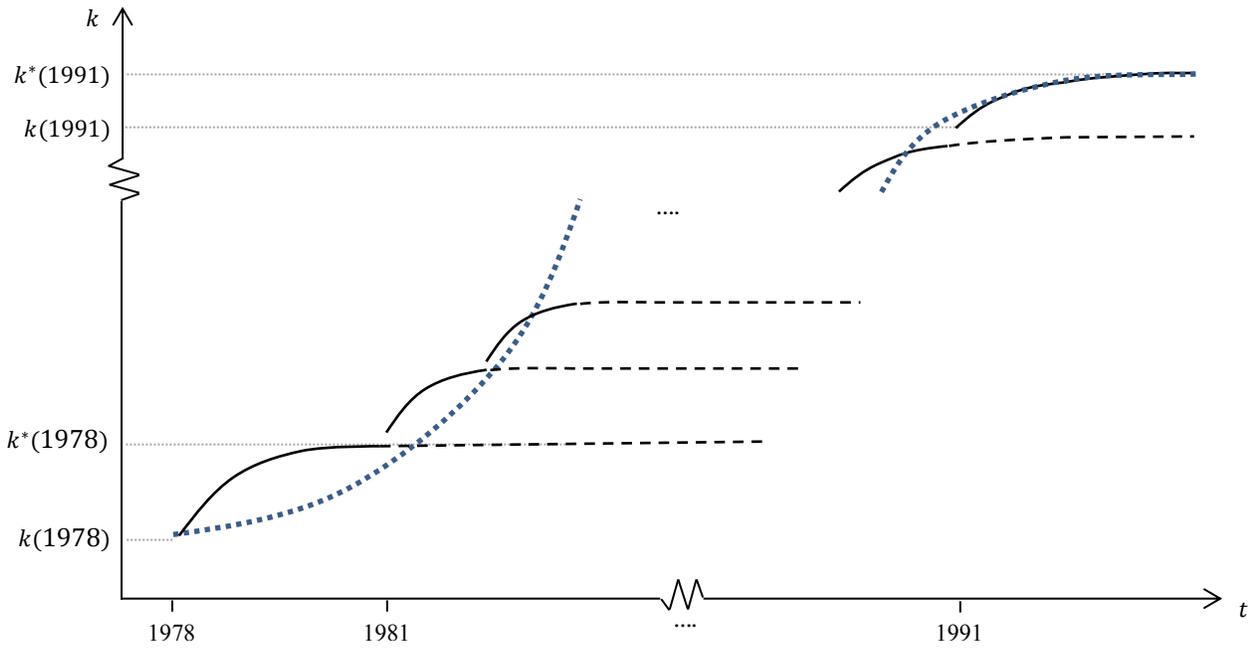
This discussion is summarized in the diagrams of Figure 4, which depict the dynamics of our model given the parameterization introduced in Section 3.2.1.1 and the reform-induced parameter changes discussed in Section 3.2.1.4.

Figure 4 Model dynamics over Phases 1 and 2.

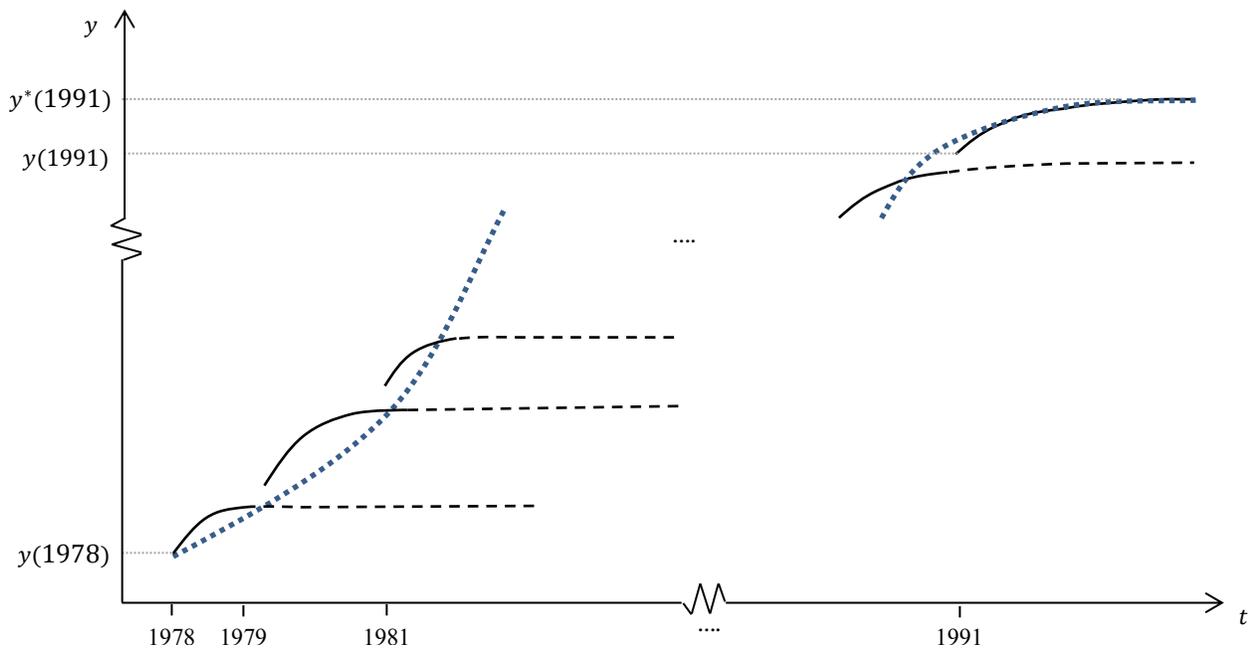
a) *Reform-induced parameter changes*



b) Dynamics of capital intensity (and trend line)¹⁴

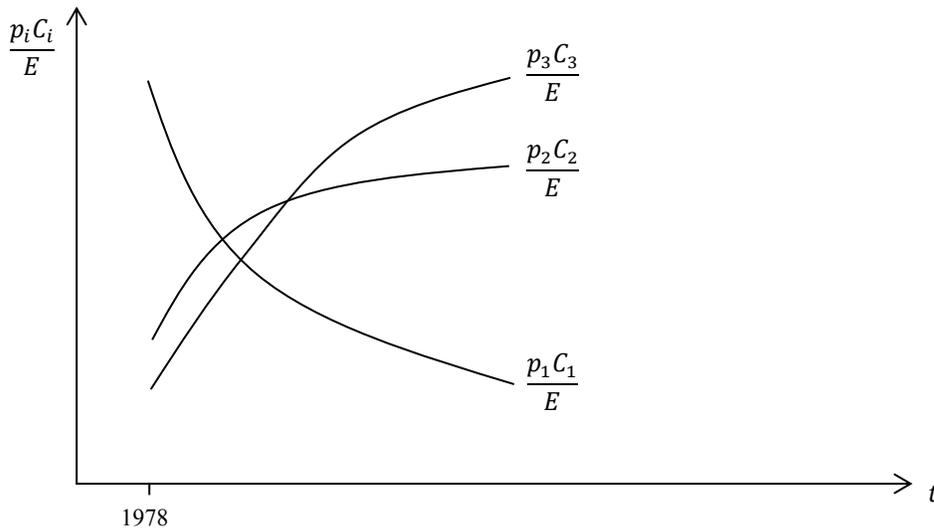


c) Dynamics of per capita GDP (and trend line)



¹⁴ The trend lines in Figures 4b and 4c are depicted by the dotted blue lines.

d) Dynamics of the consumption structure¹⁵



Overall, our model and discussion imply that the reforms of the first two phases and their timely order make sense and generate continuously growing per capita GDP. Nevertheless, our model also suggests that none of the reforms generates sustained growth. In other words, despite the reforms of the first two phases, the growth rate of the per capita GDP declines after 1991 and converges to zero over time (see Figure 4) unless further reforms are implemented, that is a third phase of reforms is initiated. Before we discuss this phase, we turn briefly to the effects of the decentralization/liberalization and trade liberalization that took place over the first and second phases.

3.2.1.6 Effects of decentralization and liberalization over Phases 1 and 2

During the first and second reform phases, the Chinese Government liberalized the sectoral prices and gradually decentralized the decisions on production quantities and factor allocation, such that over these phases the economy gradually became a decentralized/market economy. Standard (neoclassical) allocation theory provides the conditions for optimal allocation. If the decentralized economy led to a more optimal allocation in comparison with the planned economy, decentralization would cause an increase in productivity (according to the neoclassical allocation theory). Since the decentralization/liberalization was accomplished gradually over the first and second

¹⁵ Implications of the preference structure, with standard parameterization and the assumption that E grows.

(and third) phases, the efficiency increases may be interpreted as transitory growth (of GDP) similar to the gradual efficiency increases due to the HRS and TVE reforms. The effects of decentralization/liberalization are a large topic extending far beyond the scope of this paper, in which aspects such as optimal incentives and market failure play an important role. Therefore, we omit this discussion here and point to the extensive literature on this topic.

3.2.1.7 Open economy aspects

The growth model of the previous sections neglects international trade. The empirical evidence discussed in Section 2.1 implies the following stylized facts about Chinese trade, which were persistent over all three reform phases:

- 1) a gradually increasing share of exports in GDP since 1978;
- 2) a changing export structure since 1978: in 1978 the shares of manufacturing and agriculture in exports were approximately equal; then the export structure gradually shifted away from agriculture and towards manufacturing;
- 3) a growing share of agriculture in imports and a declining share of manufacturing in imports.

Our models implies that these trends uniformly enforced the shift from agriculture to manufacturing and the growth effects via Growth Source 1a derived in the closed-economy setting of Section 3.2.1.5 (see also Figure 4d). For a detailed discussion of these (static) efficiency/productivity gains of international trade (which generate transitory growth in our model), see for example the Heckscher–Ohlin model.

3.2.2 The third reform phase

The third-phase reforms primarily dealt with the fostering of FDI (and the further liberalization of trade). The (static and dynamic) effects of trade liberalization and FDI on the economic structure and growth are studied extensively in the literature. For example, the classical trade contributions (for example the Heckscher–Ohlin model and the Ricardian literature) focus primarily on the potential (positive) static productivity/welfare effects; for an overview of the dynamic effects of trade, see for example Wagner (1997), and for an overview of the effects of FDI, see for example

Keller (2004). For these reasons we do not discuss a full-scale open-economy model for China but rather the effects of FDI on the basis of the model developed in the previous sections.

FDI has two major effects on the economy. First, capital is accumulated. In general not all capital goods (for example machines) associated with FDI are imported, but part of the capital associated with FDI is produced in China. This fact implies that FDI generates a shift of production factors to manufacturing (cf. (15a)). The empirical evidence (see Section 2) implies that, initiated by Deng Xiaoping's southern tour and the subsequent FDI-enhancing policies, the third phase began with a jump in FDI. Afterwards, the FDI grew continuously (at a constant rate). Thus, continuing FDI counteracted the tendency of capital accumulation to slow down at the end of the second phase, as postulated at the end of Section 3.2.1.5 (see also the discussion of Growth Source 5). Our model implies that this capital accumulation is associated with the per capita GDP growth (cf. Growth Source 5). Second, the productivity level of production increases due to FDI, since (superior) foreign production methods and technologies are used in the facilities associated with FDI to some extent. Thus, FDI acts like (transitory) productivity growth (cf. Growth Source 6), affecting y growth directly and indirectly via capital accumulation (cf. Growth Source 5).

These effects of FDI can be approximated in our model by assuming a sequence of k^* increases and A_i increases over the third phase. We omit this modeling, since it is very similar to the modeling presented in the previous sections.

As noted previously, China's economic environment during the third phase could/should be modeled as a market economy. Thus, for example, the cross-sector factor allocation (f_i) is not exogenous but determined by the market during the third phase. This fact could be modeled by the assumption that optimal cross-sector allocation is established over the third phase (for example marginal productivities of factors are equal across sectors; see Kongsamut et al., 2001, for the optimality conditions). We omit the modeling of this aspect, since it does not change our results regarding the FDI effects on the Chinese economy.

Overall, the FDI over the third phase counteracts the slowdown tendencies with respect to the capital accumulation and per capita GDP that exist at the end of the second phase. Of course, this counteracting effect exists only as long as China succeeds in sustaining the high growth rate of FDI. Otherwise, the capital accumulation and y growth (will) slow down at some time (in the future).

4 Our model as an MIT model: Comparison with the Dabús et al. (2016) MIT explanation

Dabus et al. (2016) show that, in the Argentinian case, an exogenous impulse, and in particular an increase in the world prices for agricultural goods, induced several stages of growth. Among others, the increase in agricultural prices allowed for additional gains from trade, which were used for investment in capital and human capital accumulation. These investments generated GDP growth over some period of time. However, as shown by Dabús et al. (2016), these investments generated *transitory* growth only (and not permanent/equilibrium growth). That is, the investment generated primarily a temporary increase in the growth rate. Thus, lacking further (exogenous) impulses, Argentina's growth slowed down and remained slow, the latter aspect being interpreted as an Argentinian MIT. Overall, the idea of Dabús et al.'s (2016) paper is that a country may start growing due to an exogenous impulse that generates transitory growth; thus, after experiencing a period of strong growth, the growth rate declines and the country is regarded as being in an MIT (provided that the transitory growth push was sufficiently strong for the country to reach the middle-income range).

In our paper we choose a similar modeling philosophy for modeling China's growth process. However, in contrast to Argentina, the Chinese GDP growth since 1978 has not been driven by an exogenous market price shock and follow-up market-endogenous processes but by the Deng Xiaoping reform process. That is, in the Chinese case, the Deng Xiaoping reforms were the "exogenous impulse" that (among others) has driven the Chinese GDP growth since 1978. This fact is well known in the literature on Chinese reforms and growth (see for example Yao, 1999; Chow, 2004; Zheng et al., 2009; Zhu, 2012; Wei et al., 2017).

Moreover, in contrast to Dabús et al. (2016), who provide a *market-endogenous* explanation of strong transitory growth in Argentina (following the exogenous impulse), our paper suggests and discusses a relatively simple *market-exogenous* explanation for a potential Chinese MIT: our neoclassical modeling approach implies that the Chinese growth since 1978 was created by a series of reforms that generated a series of transitory growth phases. That is, in 1978 China had large potential for transitional-growth-generating reforms; it accomplished the middle-income range by gradually exploiting the growth potential of the reforms, and if/when this potential for (simply/readily) enforceable reforms is exploited, China's growth will slow down and thus the country will face the danger of an MIT. Of course, it is possible that nowadays China still has potential

for transitional-growth-generating reforms; thus, it may leave the middle-income range (and thus avoid an MIT) by exploiting these reforms. However, it seems to be a risky strategy to rely on such future reforms for many reasons, and the danger of a Chinese MIT should not be underestimated.

5 Concluding remarks

Overall, our model has shown that the empirical evidence on the reforms and the macroeconomic data (growth regressions and sectoral data) can be unified consistently in a neoclassical growth model implying that China's growth since 1978 has been transitory in nature and thus China's growth rate may slow down in future unless further growth sources are activated. In particular, our model implies that, among all the reforms, the third-phase reforms have the potential to create further growth if China succeeds in accumulating further capital via FDI (which requires ensuring a high growth rate of FDI in the future) and exploiting the technological progress embodied in the FDI (from advanced economies). Moreover, a natural sequel to the reforms since 1978 seems to be a reform of the service sector (or at least attraction of FDI to the service sector), which seems to be a difficult yet inevitable task in general (see also Baumol, 1967 and Wagner, 2015): (the demand side of) our model implies that, with a growing GDP, the service share becomes greater and greater. Our model predicts (in accordance with the standard literature) that the service sector will become by far the largest sector of the Chinese economy in the future; thus, the future factor productivity will depend on the productivity of the service sector. In other words, even if the reforms of the primary and secondary sectors succeeded in generating permanent growth of TFP in the agricultural and manufacturing sectors, this cannot ensure high growth rates in later stages of development, when services constitute the greatest part of the GDP; thus, high growth of the GDP in later stages of development requires high TFP growth in the service sector.

All models simplify and thus focus on some aspects of the modeled topic while neglecting others. The same is true of our model: it reflects our views of the essential reforms since 1978 and their potential effect on the future Chinese growth. In particular, we chose the framework of neoclassical growth theory and showed that it implies that China will enter an MIT unless further reforms are pursued. It allows us to develop and discuss potential policy measures against a potential MIT. Of course, it is possible and may be interesting to create alternative growth models of China

incorporating endogenous growth effects. This seems to be an interesting topic for further research.

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Appendix 1 Proof of demand side results

The representative household maximizes its lifetime-utility given by equations (1)-(4) subject to equation (5).

$$(A.1) \quad H = \frac{C(t)^{1-\theta}-1}{1-\theta} + \psi[xW + wN - \sum_i p_i C_i],$$

where ψ is the co-state variable. Optimality conditions are given by:

$$(A.2a) \quad \frac{\partial H}{\partial C_i} = C^{-\theta} \sigma_i \frac{C}{C_i - \bar{C}_i} - \psi p_i = 0$$

$$(A.2b) \quad -\frac{\partial H}{\partial W} = -\psi x = -\rho\psi + \dot{\psi} \Rightarrow x = -\frac{\dot{\psi}}{\psi} + \rho$$

From (A.2a) we obtain

$$(A.3) \quad C^{1-\theta} \frac{\sigma_i}{p_i} \frac{1}{C_i - \bar{C}_i} = \psi$$

It follows from (A.3) that

$$(A.4) \quad \frac{\sigma_i}{p_i} \frac{1}{C_i - \bar{C}_i} = \frac{\sigma_j}{p_j} \frac{1}{C_j - \bar{C}_j}$$

$$(A.5) \quad \frac{\sigma_i p_j}{p_i \sigma_j} (C_j - \bar{C}_j) + \bar{C}_i = C_i$$

Inserting (A.5) in (8) yields

$$(A.6) \quad E \equiv \sum_i p_i C_i = \sum_i \sigma_i \frac{p_j}{\sigma_j} (C_j - \bar{C}_j) + \sum_{i=1}^3 p_i \bar{C}_i$$

and, thus (considering equation (9)),

$$(A.7) \quad E = \frac{p_j}{\sigma_j} (C_j - \bar{C}_j) + \bar{C}$$

$$(A.8) \quad E - \bar{C} = \frac{p_j}{\sigma_j} (C_j - \bar{C}_j)$$

Inserting (A.8) in (A.5) yields

$$(A.9) \quad \frac{\sigma_i}{p_i} (E - \bar{C}) + \bar{C}_i = C_i$$

Inserting (A.9) in (2) yields

$$(A.10) \quad C \equiv \prod_i (C_i - \bar{C}_i)^{\sigma_i} = \prod_j \left[(E - \bar{C}) \frac{\sigma_j}{p_j} \right]^{\sigma_j} = (E - \bar{C}) \prod_j \left(\frac{\sigma_j}{p_j} \right)^{\sigma_j}$$

Inserting (A.10) in (A.3) yields

$$(A.11) \quad (E - \bar{C})^{1-\theta} \left(\prod_j \left(\frac{\sigma_j}{p_j} \right)^{\sigma_j} \right)^{1-\theta} (E - \bar{C})^{-1} = \psi$$

Inserting (10) in (A.11) yields

$$(A.12) \quad (E - \bar{C})^{-\theta} p^{1-\theta} = \psi$$

and, thus,

$$(A.13) \quad \frac{\dot{\psi}}{\psi} = -\theta \frac{\dot{E} - \dot{\bar{C}}}{E - \bar{C}} + (1 - \theta) \frac{\dot{p}}{p}$$

From (A.2b) and (A.13) we obtain

$$(A.14) \quad x - \rho = \theta \frac{\dot{E} - \dot{\bar{C}}}{E - \bar{C}} - (1 - \theta) \frac{\dot{p}}{p}$$

$$(A.15) \quad \frac{x - \rho}{\theta} + \frac{1 - \theta}{\theta} \frac{\dot{p}}{p} = \frac{\dot{E} - \dot{\bar{C}}}{E - \bar{C}}$$

From (A.15) and (7) we obtain equation (6a).