Economics Bulletin

Volume 43, Issue 2

Price of investment goods and structural change: analysis of the Korean economy

Lhakpa Sherpa
The University of the South

Abstract

Using the Korean economy to calibrate a two-sector growth model, I study the quantitative effects of price of investment goods on the process of structural change. The model is able to match several features of the economy and has implications for sectoral value-added and employment shares. In particular, I find that the decline in the price of investment goods decreases the value-added and employment shares in the agricultural sector.

Citation: Lhakpa Sherpa, (2023) "Price of investment goods and structural change: analysis of the Korean economy", *Economics Bulletin*, Volume 43, Issue 2, pages 978-991
Contact: Lhakpa Sherpa - lhsherpa@sewanee.edu.
Submitted: January 06, 2022. **Published:** June 30, 2023.

1. Introduction

Structural change, where production of non-agricultural goods increases relative to agricultural goods, is a salient feature of any growing economy. This fact was documented in earlier work by Rothbarth (1941), Chenery (1960) and Kuznets (1957), among others. More recently, Herrendorf et al. (2014) document this phenomenon for a larger group of countries, including those that grew rapidly in recent times like Japan and Korea. In this paper, I quantify the role of price of investment (capital) goods in structural change. I do so by analyzing a two-sector growth model that is calibrated to the Korean economy. The Korean economy presents itself as a suitable laboratory because of the decline in price of investment goods (figure (3)) following several industrial reforms (Jung-ho (1993), Westphal (1990), Rodriguez & Rodrik (2000)) during the second half of the twentieth century. Concurrent to this decline in the price of investment goods, the economy also had a drastic shift from the agricultural to the non-agricultural sector. Figures (1) and (2) show the employment and value-added shares in the agricultural sector between 1970 and 2005[1]. In our analysis, we study a model where reforms are conceptualized as removal of distortions that make investment goods expensive[2]. These distortions are calibrated to match the price of investment goods. We then study a counter-factual economy where reforms are absent to quantify the effect of the decline in investment prices on structural change.

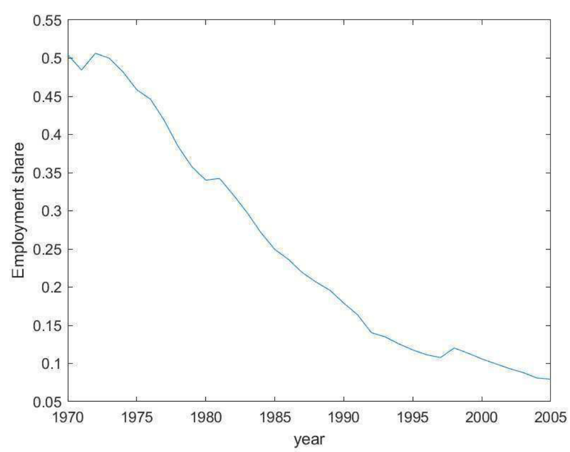

Fig. 1. Employment share in agriculture in Korea. Source: World Bank

[1] I restrict data to this period because the value-added share didn't start to decline until mid-1960s. Investment price also started declining around the same time and flattened around 2005 before the global financial crisis.

[2] The approach is similar to Buera & Shin (2013)

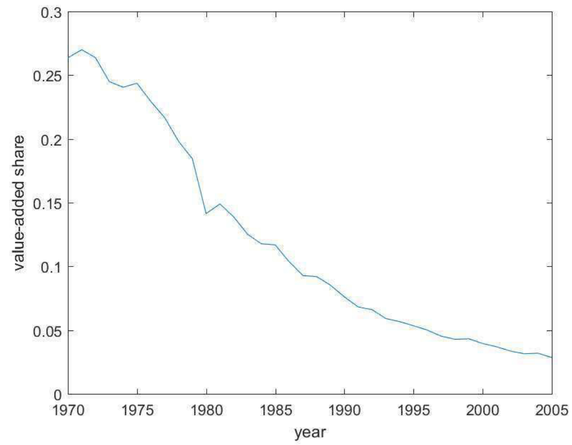

Fig. 2. Value added share in agriculture in Korea. Source: Bank of Korea

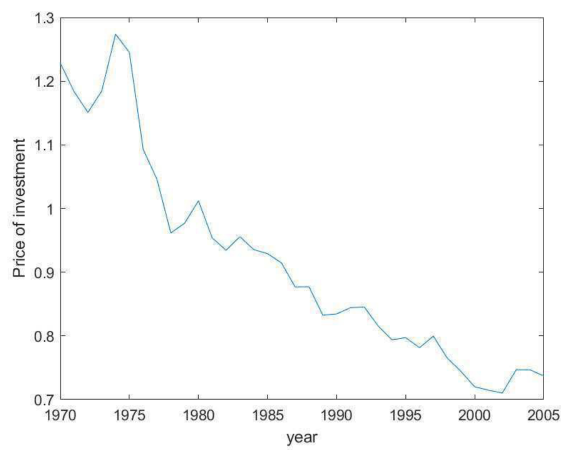

Fig. 3. Relative price of investment. Source: Penn World Table 7.1

This paper is among several other papers that have studied the phenomenon of structural change. On the theoretical side, two seminal papers by Kongsamut et al. (2001) and Ngai & Pissarides (2007) generate structural change in their models using non-homotheticity of preferences and differential productivity growth between sectors respectively. Acemoglu & Guerrieri (2008) construct a model of non-balanced growth where sectors differ in their factor shares. Their model predicts an increase in output, accompanied by a decrease in the capital and employment in the capital-intensive sector. Buera & Kaboski (2012) build a model in which high-skilled and specialized labor contributes to the increase in the service sector. Matsuyama (2009) studies structural change in the context of an open economy and argues for a global view to understand the patterns of structural change in the world economy. Besides theories, there is a burgeoning literature attempting to quantify the role of different factors that bring about structural change. For example, Buera & Kaboski (2009) examine whether traditional theories can quantitatively explain structural change in the US Buera et al. (2011) quantify the role of financial friction in the allocation of factors between manufacturing and service sectors. A number of papers have looked at the role of trade in facilitating structural change. For examples, see Uy et al. (2013), Sposi (2019), Betts et al. (2017), Teignier (2018). This paper is also related to the literature on the importance of capital accumulation during the growth process. For example, Young (1994) and Young (1995) highlight the role of increasing investment rates in explaining growth miracles in East Asian countries. Cai et al. (2015) also study the effect of declining price of investment in the context of the Korean economy. While they focus on the effects on GDP, this paper focuses on the accompanying structural change. Similar to our paper, Ghate et al. (2016) also study the effects of policy reforms on growth in a multi-sector economy. They find that the effectiveness of policy reform depends on the substitutability between the two different types of capital.

In our paper, the model economy is divided into the agriculture and non-agriculture sectors. The agriculture sector uses just labor whereas the non-agriculture sector uses capital and labor. This is different from the traditional classification of agriculture, manufacturing and service sectors. As pointed out by Buera & Kaboski (2009), traditional models cannot replicate the patterns of structural change when the economy is divided into three sectors. Since it is not our goal to match the patterns, and additionally, manufacturing and service sectors are generally modeled as having the same capital intensity (e.g., Herrendorf & Valentinyi (2012)), we build a parsimonious two-sector model.

The model and quantitative analysis are presented in the following sections.

2. Model

The model is a two-sector growth model, with an agricultural sector and a non-agricultural sector that builds on the multi-sector growth model developed by Kongsamut et al. (2001). Similar to their model, structural change stems from non-homothetic preferences of households, which results in declining income elasticity of agricultural goods relative to non-agricultural goods.[3]

Agricultural goods are only used for consumption while the non-agricultural good can be used for consumption and investment. There is a representative household in the economy that is infinitely lived and consumes these two goods. The consumption of agricultural good is represented as C_t^1 and the consumption of non-agricultural good is represented as C_t^2. The objective of the household is to maximize its lifetime utility given by

$$\sum_{t=0}^{\infty} \beta^t u(C(C_t^1, C_t^2)). \tag{1}$$

where $0 < \beta < 1$ is the discount factor. The per-period utility function satisfies $u' > 0$, $u'' < 0$, $\lim_{c\to 0} u'(C) = \infty$ and $\lim_{C\to\infty} u'(C) = 0$. $C(C_t^1, C_t^2)$ is a constant elasticity of

[3] This is referred to as the Engel effect. In the literature structural change is also generated by allowing the relative price of agricultural sector to decrease over time, known as the Baumol effect. As discussed in Buera & Kaboski (2009), including both channels is inconsistent with balanced growth.

substitution function that aggregates the consumption goods - i.e.

$$C(C_t^1, C_t^2) = \left[\theta(C_t^1 - \bar{c})^{\frac{\epsilon-1}{\epsilon}} + (1-\theta)(C_t^2)^{\frac{\epsilon-1}{\epsilon}}\right]^{\frac{\epsilon}{\epsilon-1}},$$

where $0 < \theta < 1$ is the share of agricultural good and $\epsilon \geq 0$ is the elasticity of substitution between the two consumption goods. $\bar{c} > 0$ is subsistence level of consumption. This parameter makes the household preference non-homothetic. In particular, the Engel curve is non-linear and the relative demand for the non-agricultural good increases as income increases.

The size of the household is given by L_t, which grows at a constant gross rate g_n. The household maximizes its lifetime utility subject to the per-period budget constraint,

$$p_t C_t^1 + C_t^2 + \tau_t I_t = R_t K_t + w_t L_t. \tag{2}$$

The left hand side of the constraint is the expenditure and the right hand side is the income of the household. The price of non-agricultural good is normalized to one. τ_t is a distortion to capital accumulation, which makes investment good expensive. Aggregate capital accumulates according to the law of motion given by:

$$K_{t+1} = I_t + (1-\delta)K_t. \tag{3}$$

There are two representative firms producing the two goods in the economy. The production functions differ in terms of the factors of production they use. The agricultural good is produced using labor only.

$$Y_t^1 = z_t L_t^1.$$

The non-agricultural good is produced using a constant returns to scale Cobb-Douglas production function. Unlike the agricultural sector, the non-agricultural sector uses both capital and labor.

$$Y_t^2 = K_t^\alpha (z_t L_t^2)^{1-\alpha}.$$

I assume that z_t grows at a constant rate g_z over time.

The resource constraint for labor is given by

$$L_t^1 + L_t^2 = L_t, \tag{4}$$

where L_t is the total labor supplied by the household.

The resource constraints for the two goods are given by:

$$C_t^1 = Y_t^1, \tag{5}$$

$$C_t^2 + \tau_t I_t = Y_t^2. \tag{6}$$

Competitive Equilibrium

The competitive equilibrium is given by allocations $\{C_t^1, C_t^2, I_t, K_t, L_t^1, L_t^2\}_{t=0}^{\infty}$, *prices* $\{p_t, w_t, R_t\}_{t=0}^{\infty}$ *and the distortions* $\{\tau_t\}_{t=0}^{\infty}$, *such that*

1. *Taking prices as given, the household maximizes its lifetime utility (1) subject to the budget constraint (2).*
2. *Taking prices as given, both the firms maximize their profits.*
3. *Markets clear for labor, capital and outputs. I.e. equations (4) - (6) hold and capital supplied by the household equals capital demanded by the firm in the non-agricultural sector.*

3. Quantitative Analysis

In my analysis I use the CRRA utility function of the form

$$u(C) = \frac{C^{1-\sigma}}{1-\sigma}.$$

The first order conditions that characterize the solution of the model is given by:

$$C_t^2 = \left(C_t^1 - \bar{c}\right)\left(\frac{1-\theta}{\theta}p_t\right)^{\epsilon},$$

$$\left(\frac{C_{t+1}^2}{C_t^2}\right)^{\sigma} = \beta\frac{h(p_t)}{h(p_{t+1})}\left[\frac{\alpha}{\tau_t}K_{t+1}^{\alpha-1}(z_{t+1}L_{t+1}^2)^{1-\alpha} + \frac{\tau_{t+1}}{\tau_t}(1-\delta)\right],$$

$$p_t = (1-\alpha)K_t^{\alpha}(z_t L_t^2)^{-\alpha},$$

$$C_t^2 + \tau_t K_{t+1} = K_t^{\alpha}(z_t L_t^2)^{1-\alpha} + \tau_t(1-\delta)K_t,$$

$$C_t^1 = z_t L_t^1,$$

$$L_t^1 + L_t^2 = L_t,$$

where

$$h(p_t) = \left[\theta\left(\frac{\theta}{1-\theta}\frac{1}{p_t}\right)^{\epsilon-1} + 1 - \theta\right]^{\frac{\epsilon\sigma-1}{\epsilon-1}}. \tag{7}$$

The degree of structural change is demonstrated by changing employment share and value-added share in different sectors. Equating the marginal product of labor across sectors, we find the labor allocated to the non-agricultural sector,

$$L_t^2 = (1-\alpha)^{\frac{1}{\alpha}}\frac{K_t}{z_t p_t^{\frac{1}{\alpha}}} \tag{8}$$

The labor share in the non-agricultural sector goes up when capital goes up. This is intuitive because an increase in the level of capital increases the marginal product of labor in the non-agricultural sector, so there is a movement of labor into this sector.

The value-added share of the agricultural sector, VA, is given by:

$$VA = \frac{1-\alpha}{1-\alpha+\frac{L_t^2}{L_t^1}} \tag{9}$$

The value-added share has a one-to-one relation with the ratio of the labor shares. Specifically, the value added shares decreases when the employment shares in the non-agricultural sector relative to the agricultural sector increases. Therefore, the distortion in the price of investment affects the value added shares in the agricultural (and therefore the non-agricultural) sector to the extent it affects the reallocation of labor from the agricultural to the non-agricultural sector and vice-versa.

3.1 Calibration

Due to non-homotheticity of the utility function, a balanced growth path only exists asymptotically. Like Buera & Kaboski (2009), I study the transition to this balanced growth path. There are several preference and technology parameters along with the sequence for distortions $\{\tau_t\}$ that need to be calibrated.

We take data from the Korean economy focusing particularly between the period 1970-2005. A period in the model corresponds to a year in the data. Table (I) lists the parameters and their values taken directly from the literature or data.

Pre-determined parameters

β	0.97
σ	2.0
α	0.33
δ	0.06
g_n	1.01

Table I.

The values for $\{\beta, \sigma, \alpha, \delta\}$ are all standard. The value for g_n is the growth rate of population, which equals 1.011 and the initial population is normalized to one. The data is available in the Penn-World Table 7.1.[4]

The remaining parameters are $\{\bar{c}, \theta, \epsilon, z_0, g_z, k_0\}$. These parameters are jointly calibrated to minimize the sum of the square of the difference between the output per capita, employment

[4] Check http://pwt.econ.upenn.edu/php_site/pwt_index.php.

shares in the agricultural sector and relative price of agricultural goods in the model and the data. The data come from a few different sources. Output per capita and employment shares are available from the World Bank Indicators. The relative price of agricultural goods is constructed using the data from OECD.[5] The parameter values are presented in table (II).

Calibrated parameters

$\bar{c}$	0.49
θ	0.15
ϵ	1.55
z_0	1.09
g_z	1.05
k_0	0.97

Table II.

The parameter ϵ is an important parameter in the literature. In a Ngai & Pissarides (2007) environment $\epsilon < 1$ is required to generate a balanced growth path. This restriction is crucial when the relative price of sectoral goods are growing as well. In our model, the relative price changes in the short-run but asymptotically remains unchanged, and hence the restriction is not important for the asymptotic balanced growth path.

It remains to find the sequence $\{\tau_t\}$. These distortions are inferred from the data on relative price of investment good. To infer the sequence of distortions, we equate the relative price of investment in the model to the data. I.e.

$$\frac{\tau_t}{P_t} = \chi_t, \tag{10}$$

where χ_t is the relative price of investment in the data and P_t is the composite price of consumption good given by

$$P_t = \left[\theta^\epsilon (p_t)^{1-\epsilon} + (1-\theta)^\epsilon\right]^{\frac{1}{1-\epsilon}}.$$

Figure (4) shows the price of the investment good and a second degree polynomial that approximates the price. This second-degree polynomial approximation is fed into the model for the period 1970-2005. For the remaining periods the price is fixed at the level of 2005.

[5]Check https://stats.oecd.org/.

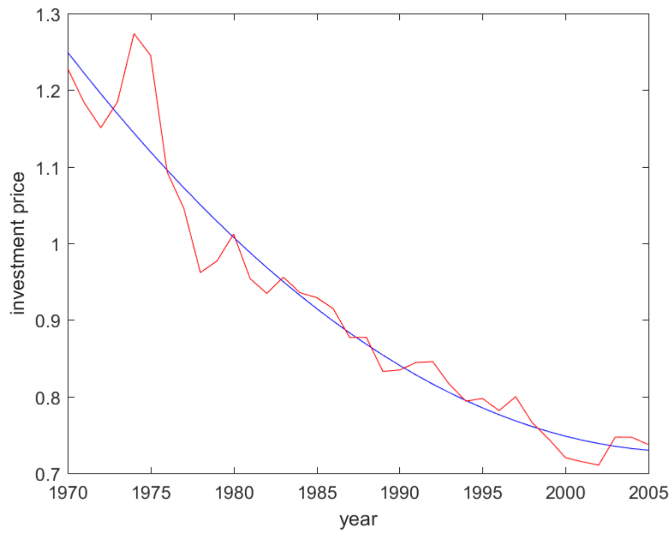

Fig. 4. Relative price of investment

The values of $\{\tau_t\}$ is given in figure (5).

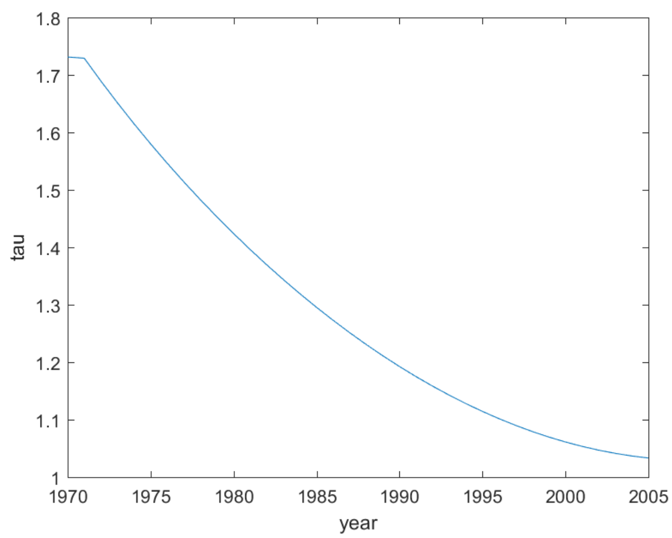

Fig. 5. Values of τ_t

To check the model's performance, I begin by comparing output per capita from the model and the data. As can be seen in figure (6) the model is able to mimic output per capita well. Similarly, figure (7) compares employment shares in the agricultural sector from the model and the data.

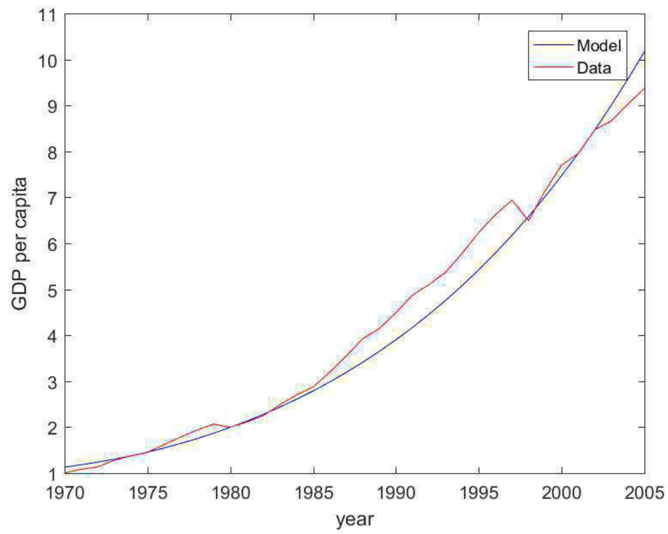

Fig. 6. Output per capita

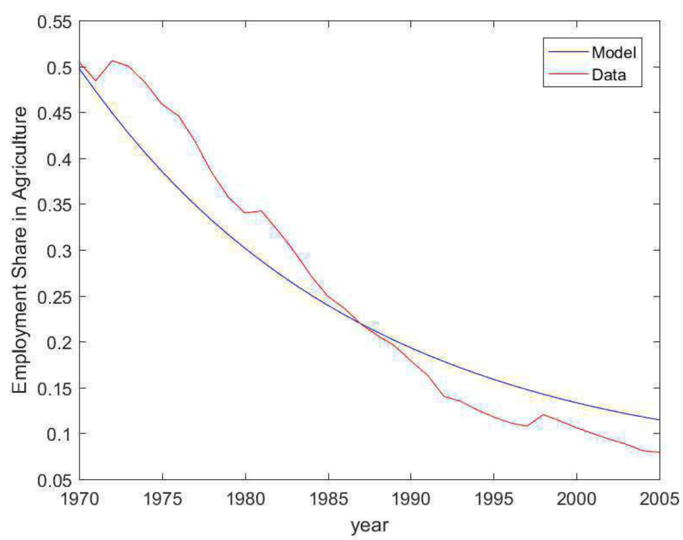

Fig. 7. Employment shares of agriculture

The model is also able to produce the well-documented fact of increasing and high investment rate in the Korean economy during the second half of the twentieth century. (e.g. Young (1994), Young (1995)) The model is able to produce this pattern for investment rate quite well. As noted by Cai et al. (2015) a one-sector model produces a U-shaped pattern for investment rate, which is inconsistent with what is observed in the data.

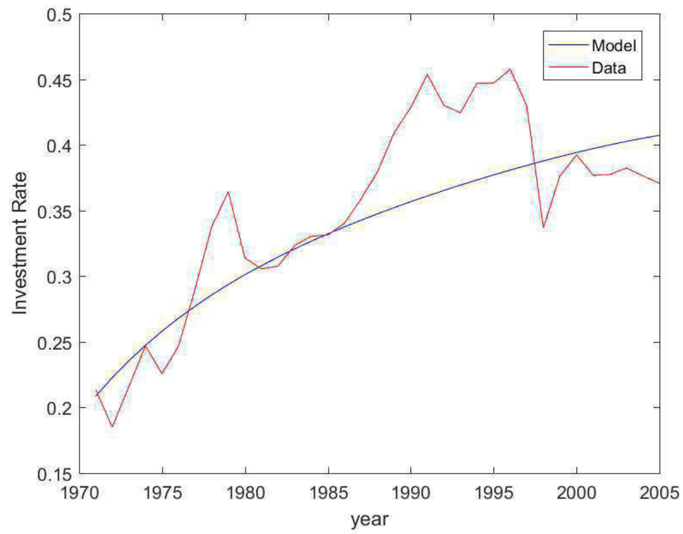

Fig. 8. Investment rate

I now use the model to quantify the effect that reforms have had on structural change. For this, I compare a counterfactual case in which the values of distortion τ_t is kept at the 1970 level to the case where they are derived from the data. I call the former the pre-reform and the latter the post-reform version of the economy. The initial conditions in the models are the same as in the previous economy.

In order to compare the value-added and employment shares of agriculture, I compute the ratios of these variables in the pre-reform economy relative to that in the post-reform economy. Table (III) lists these ratios by decade. As can be seen, the ratios start to increase as time passes. In 2005, the value-added share in the pre-reform economy is 7% higher than that in the post-reform economy. Similarly, the employment share in agriculture is also 7% higher in the pre-reform economy relative to the post-reform economy. To put it in context, the employment share in the post-reform economy is 11.4% in 2005, so when employment share is 7% higher in the pre-reform economy, around 300,000 more are employed in the agricultural sector.[6] Both employment and value-added shares in the pre-reform economy stabilize around 10% higher than those in the post-reform economy in the long-run.

[6]This number is computed by multiplying 0.07 by the working age population in the economy employed in the agricultural sector.

Value-added shares and employment shares in agriculture

Year	Employment shares (Pre/Post)	Value-added shares (Pre/Post)
1970	1.00	1.00
1980	1.01	1.01
1990	1.02	1.02
2000	1.05	1.06
2005	1.07	1.08
2020	1.10	1.11

Table III.

The difference in the post and pre-reform economies is the sequence of investment prices, which affects the rate of investment under the two regimes. Table (IV) compares investment rates in the two economies. Investment rate is generally higher in the pre-reform economy, especially in the early years, suggesting that substitution effect dominates income effect when price falls after reform. However, a higher level of investment and substitutability between agricultural and non-agricultural goods generates a reallocation between the two sectors.

Investment rates

Year	Investment Rate (Pre/Post)
1970	1.11
1980	1.06
1990	1.04
2000	1.00
2005	0.99
2020	0.99

Table IV.

4. Concluding Remarks

This paper studies the effects of decline in investment prices, brought about by economic reforms, on the process of structural change. Economic reforms are represented by the level of distortion present in investment of capital. Using the Korean economy to calibrate a two-sector growth model, the paper compares an economy in which reforms take place with one where they don't. I find that the reforms have implications for sectoral value-added and employment shares and investment rates in the economy. In particular, the post-reform economy generates a higher employment and value-added shares in the non-agricultural sector.

This research can be extended by incorporating difference in productivity across sectors. For example, the change in sectoral productivity can have implications for the structural change in the economy. A balanced growth path would cease to exist if this channel was incorporated in the current model. But comparing the outcomes of this model to one where there is productivity growth differentials can potentially provide further insights.

References

Acemoglu, D., & Guerrieri, V. (2008). “Capital deepening and nonbalanced economic growth.” Journal of Political Economy, 116(3), 467–498.

Betts, C., Giri, R., & Verma, R. (2017). “Trade, reform, and structural transformation in South Korea.” IMF Economic Review, 65(4), 745–791.

Buera, F. J., & Kaboski, J. P. (2009). “Can traditional theories of structural change fit the data?” Journal of the European Economic Association, 7(2-3), 469–477.

Buera, F. J., & Kaboski, J. P. (2012). “The rise of the service economy.” American Economic Review, 102(6), 2540–69.

Buera, F. J., Kaboski, J. P., & Shin, Y. (2011). “Finance and development: A tale of two sectors.” American Economic Review, 101(5), 1964–2002.

Buera, F. J., & Shin, Y. (2013). “Financial frictions and the persistence of history: A quantitative exploration.” Journal of Political Economy, 121(2), 221–272.

Cai, W., Ravikumar, B., & Riezman, R. G. (2015). “The quantitative importance of openness in development.” Economic Inquiry, 53(4), 1839–1849.

Chenery, H. B. (1960). “Patterns of industrial growth.” The American Economic Review, 50(4), 624–654.

Ghate, C., Glomm, G., & Streeter, J. L. (2016). “Sectoral infrastructure investments in an unbalanced growing economy: The case of potential growth in India.” Asian Development Review, 33(2), 144–166.

Herrendorf, B., Rogerson, R., & Valentinyi, Á. (2014). “Growth and structural transformation.” Handbook of Economic Growth, 2, 855–941.

Herrendorf, B., & Valentinyi, A. (2012). “Which sectors make poor countries so unproductive?” Journal of the European Economic Association, 10(2), 323–341.

Jung-ho, Y. (1993). “The political economy of protection structure in Korea.” Trade and Protectionism, 2, 361–385.

Kongsamut, P., Rebelo, S., & Xie, D. (2001). “Beyond balanced growth.” Review of Economic Studies, 68(4), 869–882.

Kuznets, S. (1957). “Quantitative aspects of the economic growth of nations: II. industrial distribution of national product and labor force.” Economic Development and Cultural Change, 5(S4), 1–111.

Matsuyama, K. (2009). “Structural change in an interdependent world: A global view of manufacturing decline.” Journal of the European Economic Association, 7(2-3), 478–486.

Ngai, L. R., & Pissarides, C. A. (2007). “Structural change in a multisector model of growth.” American Economic Review, 97(1), 429–443.

Rodriguez, F., & Rodrik, D. (2000). “Trade policy and economic growth: a skeptic's guide to the cross-national evidence.” NBER macroeconomics annual, 15, 261–325.

Rothbarth, E. (1941). “The conditions of economic progress.” The Economic Journal, 51, 120–124.

Sposi, M. (2019). “Evolving comparative advantage, sectoral linkages, and structural change.” Journal of Monetary Economics, 103, 75–87.

Teignier, M. (2018). “The role of trade in structural transformation.” Journal of Development Economics, 130, 45–65.

Uy, T., Yi, K.-M., & Zhang, J. (2013). “Structural change in an open economy.” Journal of Monetary Economics, 60(6), 667–682.

Westphal, L. E. (1990). “Industrial policy in an export-propelled economy: lessons from South Korea's experience.” Journal of Economic perspectives, 4(3), 41–59.

Young, A. (1994). “Lessons from the East Asian NICs: a contrarian view.” European Economic Review, 38(3-4), 964–973.

Young, A. (1995). “The tyranny of numbers: confronting the statistical realities of the East Asian growth experience.” Quarterly Journal of Economics, 110(3), 641–680.