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Structural Change and Income Inequality: Evidence from Thailand

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Abstract

Structural change is the contraction of agriculture as a share of both aggregate economic output and employment and the corresponding expansion of the combined shares of industry and services. First, we describe this process in the context of Thailand, a country experiencing significant structural change in recent decades. Second, we analyse its causes using a simple, comparative static computable general equilibrium model of the Thai economy, operated in long-run mode. We test the explanatory power of three hypotheses about the causes of structural change: differences in the growth rates of aggregate factor supplies (the Rybczynski effect; sectoral differences in total factor productivity growth; and the differences between commodities in expenditure elasticities of demand (Engel's law). The first two hypotheses operate on the supply-side of the economy, implying changes in the shape of the production possibility frontier (PPF). The third, a demand-side effect, implies changes in output prices during growth that induce movements around the PPF. The results indicate that the first two explanators predict the observed structural change accurately, but that the third, Engel's law, predicts poorly. Third, we use the above framework to study the impacts these drivers of structural change have on the functional distribution of incomes. The results show that the explanators of structural change do not predict the observed changes in factor income shares. We conclude that these two phenomena have different drivers and that stable empirical relationships between them should not be expected.

Key words: structural change, Thailand, computable general equilibrium model

JEL classification: O11, C60, O53

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1. Introduction

The relationships between structural change, economic growth and income inequality have been major subjects of economic research since Simon Kuznets' pioneering contribution, 70 years ago. Structural change refers to changes in the sectoral composition of GDP and employment, notably the contraction of agriculture relative to industry and services combined. In a celebrated 1955 study Kuznets initiated a new field of quantitative economic inquiry: the impact that growth and its associated structural change have on income inequality. This paper studies the relationships between these phenomena in the context of Thailand, a developing country experiencing large shifts in each of these three dimensions over recent decades and for which relatively good economic data are available. The paper asks two questions. First, what are the principal determinants of structural change? Second, are these also the determinants of changes in income inequality?

The following section provides a brief review of Kuznets' pioneering contribution, focusing on the famous 'Kuznets inverted-U hypothesis'. We then summarise recent data on growth, structural change and income inequality in Thailand. We interpret the relationships between these variables to be essentially general equilibrium phenomena and use a simple but fully specified and empirically based general equilibrium framework to investigate the above two questions. Next, we describe our general equilibrium model and discuss the findings.

The empirical findings can be summarised as follows. Significant structural change occurred in Thailand between 1990 and 2014: agriculture and services each contracted by about three percent of GDP and industry expanded by about six percent. The main sources of these structural outcomes were two supply-side forces: expanded supplies of physical capital relative to other factors; and differences in rates of sectoral productivity growth. These two explanators, especially the second, predict the observed structural changes well, but demand-side forces, such as Engel's law, predict poorly. Evidence on the shares of labour and capital in GDP at factor cost suggests that they are important correlates of the observed changes in household level income inequality. But the explanators of structural change do not predict the observed changes in factor income shares. These two sets of endogenous outcomes, structural change and income inequality, apparently have different underlying drivers. Accordingly, we should not necessarily expect stable empirica8 relationships to exist between them.

2. Kuznets and the 'inverted-U hypothesis'

Simon Kuznets' famous Presidential Address to the American Economic Association, published in 1955, posed a question of enduring importance: "Does inequality in the distribution of income increase or decrease in the course of a country's economic growth?" (Kuznets 1955, p.1). Before answering, Kuznets' lamented that this broad area of study was "plagued by looseness in definitions, unusual scarcity of data, and pressures of strongly held opinions." On the first two points, much progress has subsequently occurred, but possibly not the third. Kuznets' highly tentative answer was in four parts.

First, Kuznets reviewed the limited time series data on income distribution that were available at the time, relating to pre-tax incomes in England, Germany and the US, concluding that these data "justify a tentative impression of constancy in the relative distribution of income before taxes, followed by some narrowing of relative income inequality after the first world war – or earlier." (p. 5). This conclusion was based exclusively on observations over time for each of these three countries, taken one country at a time.[1]

Second, these empirical results were compared with Kuznets' own theory-based expectation that growth would coincide with "a downward trend in the share of lower income groups [that is, increased inequality]. Yet we find no such trend in the empirical evidence that we have." (p.16). Kuznets considered that a "puzzle". The classical economists, including Adam Smith, had argued that higher income groups saved a higher proportion of their incomes, leading to concentration of capital accumulation among these groups. Therefore, on the implicit assumption that economic growth was caused by capital accumulation alone, growth would be associated with increased inequality.[2]

Third, Kuznets then attempted to explain the divergence between the above empirical findings and the author's theory-based expectations. The explanation included a detailed, somewhat cumbersome numerical example resting on special assumptions about structural change, population growth and inequality differences within and between segments of the

[1] Later in the 1955 paper, Kuznets cited data on inequality in India, Ceylon (now Sri Lanka) and Puerto Rico, but had only one data point for each of these countries. These data were used to argue that income inequality in these 'underdeveloped' countries was generally higher than in 'developed' countries in the period shortly after World War II (pp. 20-21). But in Kuznets' writings, cross-country comparisons were never used as a basis for conclusions about the growth-inequality relationship for individual countries (Kuznets 1955, 1963, 1966).

[2] This could mean that growth produced by capital accumulation causes greater inequality, or causality in the reverse direction, or both.

population. Its outcome was that, taking account of structural change in particular, changes in inequality were the net result of counteracting economic and demographic forces, some contributing to increased inequality (like the savings argument), others the reverse.[3] The clear but unstated implication was that theory alone produced ambivalent results and could not be expected to predict reliably whether inequality would rise or fall.

Fourth, in a famous passage Kuznets then speculated that an increase in inequality may have occurred prior to the time-series data then available:

> "One might thus assume a long swing in the inequality characterizing the secular income structure: widening in the early phases of economic growth when the transition from the pre-industrial to the industrial civilization was most rapid; becoming stabilized for a while; and then narrowing in the later phases." (p. 18)

Despite the word "thus" it was not apparent that this "long swing" assumption followed from the discussion preceding it. The initial, inequality-increasing segment (Phase I) was based on conjecture, in the absence of empirical evidence. Assumptions about structural change played a central role in this discussion, but its analytical predictions were ambiguous. The subsequent inequality-stable (Phase II) and inequality-decreasing (Phase III) segments were based on data, as described above. Kuznets had already shown that theory-based predictions of increased inequality were contradicted by the available empirical evidence for England, Germany and the US during Phases II and III. Perhaps the theoretical speculation underlying the assumed inequality-increasing segment (Phase I) of the supposed "long swing" would similarly be refuted if empirical evidence could be found covering that period? Kuznets' discussion was careful and non-dogmatic, but this obvious possibility was not mentioned. In the more detailed discussions contained in the 1963 paper and the 1966 book, Kuznets dropped all reference to this "long swing" assumption.

Well-founded or not, at least in the 1955 article, Kuznets did propose the hypothesis that inequality first increases as growth proceeds, then stabilizes, then declines. But the article has since become famous, even notorious, for a proposition it did not contain: the 'inverted-U hypothesis'. In the 1955 article or in later writings (Kuznets 1963, 1966) Kuznets did not say

[3] This point was repeated at length in Kuznets (1963, pp. 65-67; and 1966, pp. 212-213).

or imply that the inequality-growth relationship resembled an inverted-U. In the 1966 book, Kuznets' empirical findings on the growth-inequality relationship were summarised in four major trends, culminating in:

> "Fourth, for the period of observation, the distribution of income by size among individuals and households, after showing stability or perhaps a slight widening in pre-World War I years, has shown a marked reduction in inequality." (p. 218)

That is different from an inverted-U, more like an inverted spoon or ladle. Nevertheless, later authors characterised Kuznets' argument with the inverted-U metaphor, wrongly attributing it to the 1955 article. The important cross-sectional study by Ahluwalia (1976) may have been the first example. Some authors even interpreted the 'inverted-U' as a form of dogma, also attributing that to Kuznets.[4] Srinivasan (1977, p. 15) called it "some sort of iron law of development", Sundrum (1990) called it "Kuznets' law" and Rodrik (1998) called it "fiction". Summarising this vast and contentious literature, Moran (2005, p. 209) described "Kuznets' inverted-U hypothesis" as "the most influential statement ever made on inequality and development". It was an "influential statement" that Kuznets never made. Even if the inverted-U was an iron law, it would not be Kuznets law.[5]

In one instance, Kuznets' wording may have misled some readers. In summarising the initial, inequality-increasing segment (Phase I) of the assumed "long swing", Kuznets called it a "conjectural conclusion" (Kuznets' 1955, p.18). A conjecture cannot also be a conclusion. More accurately, Lindert and Williamson (1985, p. 343) called this (Phase I) segment of Kuznets' "long swing" a "cautiously ventured guess". It was an explicit assumption, not a theoretical or empirical finding.

The 'Kuznets inverted-U hypothesis' remains popular with textbooks on economic development, but it distorts what Kuznets said. First, it obscures the fact that the rising, stable and falling segments of Kuznets' assumed "long swing" had different foundations, as Kuznets explained clearly. The increasing phase (I) was based on non-rigorous theoretical speculation, whereas the stable and falling phases (II and III) were based on empirical

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[4] According to the sociologist of science Stephen Fuchs, the inverted-U became "an unproblematic and largely undisputed fact that served as a 'foundation' for the new field of development economics." (Fuchs 1992, p. 211)).

[5] See Perkins *et al.* (2013, pp. 174-177) for a review of the strong empirical evidence questioning the existence of "Kuznets' inverted-U" (p. 175).

evidence, using limited data. Second, an inverted-U shape implies that the increasing and decreasing segments of the assumed "long swing" relationship (I and III) are roughly symmetrical – similar in slope and magnitude. This would imply that long-term growth eventually produces a level of inequality comparable with that experienced before the growth process began. In the meantime, higher inequality could be expected. Kuznets never suggested that.

Of course, the inverted-U story may or may not be a valid description of today's world, regardless of what Simon Kuznets said or meant to say, seven decades ago. If the inverted-U was correct today, a poor country embarking on a program of long-term economic growth based on capitalism could look forward to an extended, possibly indefinite, period of rising pre-tax income inequality (Phase I above) – just as Marx and Engels had predicted a century before Kuznets – threatening social and political stability in that country and compromising the degree to which poverty could be reduced through growth. That is, unless massive redistribution was undertaken at the same time, even if that meant lower growth. In contrast, if Kuznets' actual conclusions were correct today, tentative though they were, the necessity for redistributive policies would potentially be less. Correspondingly, growth itself would warrant greater priority. The difference matters.

Kuznets' work has come to be associated with the presumption that growth and structural change would be associated with increased inequality, especially in the early stages of the growth process. But a careful reading of the 1955, 1963 and 1966 studies shows that this was not their message. These studies were rightly ambivalent about the prospects for inequality in the early stages of growth, for which Kuznets had almost no data. But each of these studies emphasised at length the empirical evidence that long-term reductions in inequality coincided with economic growth, even before tax, qualified by recognition of the limited data available at the time. We owe it to Kuznets' pioneering contributions to describe them correctly.

3. The approach of this paper

We now turn to the questions posed in the Introduction, in the context of Thailand. Three analytical features of Kuznets' 1955 discussion are especially relevant for this paper:

(i) Kuznets treated economic growth as an exogenous and homogeneous force, originating somewhere in the background, unexplained. The sources of growth were not discussed. Kuznets therefore overlooked the possibility that different sources of growth might have different distributional consequences.[6] Deeper thinking about economic growth had to wait for Solow's classic paper, distinguishing between output growth based on increasing factor supplies and that based on productivity improvements (Solow 1957).

(ii) Kuznets' theoretical discussion of changes in income inequality, especially Phase I above, rested heavily on the implications of structural change. But Kuznets also treated structural change as exogenous, without discussing its underlying causes. The possibility arises that different drivers of structural change could affect income distribution differently. That is, Kuznets did not consider the possibility that the same observed structural change outcomes, but produced by different combinations of causal factors, could coincide with different distributional outcomes.

(iii) Similarly, changes in the various components of pre-tax incomes, including returns to capital, land and labour of different skill levels – that is, changes in the functional distribution of income – were not mentioned in Kuznets' analysis of the growth-inequality relationship. Similarly with the above two points, the discussion ignored the possibility that changes in the underlying drivers of growth could produce changing patterns of returns to the factors of production owned by different segments of the population, with resulting implications for income distribution.[7]

Figure 1 Panel a summarises the above understanding of Kuznets' conceptual framework. Aggregate growth and structural change are both treated as exogenous, without discussion of their sources, and income distribution is endogenous. The present study adopts the framework presented in Panel b. Growth, structural change and income inequality are each endogenously driven by explanators that include supply-side forces – factor accumulation and productivity growth. These forces, treated here as exogenous, must also have their determinants, but these relationships are outside the scope of this paper. The impacts that these supply-side explanators have on the endogenous variables – growth, structural change and the functional distribution of income – are in turn moderated by demand-side forces through their effects on the relative prices faced by producers.

[6] This analytical problem was recognised in Kuznets (1963): "Much of the difficulty in discussion of the topic is due to the lack of a firm theory of causes and consequences of economic growth…" (p. 2)

[7] The classical economists cited by Kuznets, including Adam Smith, emphasised changes in the functional distribution of income as determinants of overall changes in income inequality. But Kuznets said almost nothing about it.

Imagine a production possibilities frontier (PPF), describing the potential outputs (value-added) of three sectors: agriculture, industry and services. The position on that PPF at which production occurs (call that point *Y*) depends on domestic relative prices. Economic growth consists of outward shifts in the PPF, measured in terms of one of the outputs as the point at which a relative price line tangent to the PPF at *Y* intersects the axis for that commodity. The composition of GDP is represented by the slope of a ray from the origin to point *Y*. Structural change means changes in that slope.

Now consider the determinants of structural change. We shall study the explanatory power of three possible contributors to this process, each considered exogenous:[8]

(*a*) different rates of accumulation of the aggregate stocks of factors of production (the Rybczynski effect), inducing endogenous changes in the shape of the PPF;
(*b*) different rates of total factor productivity growth between the major sectors, again causing endogenous changes in the shape of the PPF; and
(*c*) differences in expenditure elasticities of demand between final consumer goods, including inelastic demand for food (Engel's law), inducing endogenous price-induced movements around the PPF.[9]

The strategy of analysis that follows is that each of these three hypotheses is considered a contributor to the structural changes and inequality changes that are observed in the data. That is, the impacts of these three explanators are assumed to be present in the observed data. We perform a sequence of counterfactual simulations each of which estimates the impact of one of these factors by *taking away* the explanator concerned, through an exogenous shock, holding all other exogenous variables constant. The impact of that explanator is then estimated as the difference between the actual structural change, as observed in the data, and the counterfactual structural change – the estimated outcome *without* that explanator.

[8] A recent paper (Warr and Yusuf 2025) considered two additional explanators: price-induced movements around the PPF induced by changes in the relative international prices of traded goods; and price-induced movements induced by changes in the country's own trade policies. In the context of Thailand, the estimated structural effects of both of these explanators were very small and the present study omits them.
[9] Textbooks on economic development typically cite Engel's law as the key reason for structural change during economic growth. Prominent examples are Perkins *et al*., (2013, p. 587) and Thirlwall and Pacheco-Lopez (2017, p. 62). See also Anderson (1987).

Assume, for now, that this exercise successfully explains structural change (we will show that it does). Will stable relationships then exist between structural change and income inequality? According to our conceptual framework (Figure 2), not necessarily. Both structural change and changes in inequality are endogenous consequences of their respective exogenous drivers. Suppose the exogenous drivers of structural change and inequality were significantly different from one another and that these drivers change over time, relative to one another. Then structural change and inequality may move together during one period and in opposite directions during another.[10] No stable relationships would exist. But now suppose their determinants were similar. Even if these exogenous drivers did change over time, structural change and inequality may then move together, creating a stable empirical relationship. We therefore propose to test the hypothesis that the drivers of structural change and changes in inequality are similar.

4. Structural change and inequality in Thailand

4.1 Structural change

Figure 2 summarises both economic growth since 1960 (vertical bars, numbers on the LHS axis), and the sectoral composition of GDP (line series, percentages on the RHS axis). Warr and Suphannachart (2022) show that the overall rate of structural change was strongly correlated with the growth of real GDP: the faster the growth, the faster the structural change. Agriculture contracted as a share of GDP throughout this period, with the rate of contraction slowing from about 2000 onwards. Agriculture's contraction was mirrored by expansion of industry, with the GDP share of services fluctuating somewhat, but changing only slightly over the long term.

Figure 3 performs a similar exercise for structural change in employment. Two differences from Figure 2 are important. First, agriculture's share of total employment far exceeds its GDP share in all years. Second, agriculture's share contracts over time, but its contraction is mirrored primarily by expansion of the share of services, not industry as in Figure 2. A rough summary of these employment data is that for every 10 percentage-point decline in the employment share of agriculture, the share of services rose by roughly 6.6 percentage-points

[10] As summarised above, Kuznets also made this argument.

and the share of industry increased by 3.4 percentage-points. Structural change looks quite different, viewed in terms of the composition of GDP and the composition of employment. The present paper focuses on the former, but the difference is notable.

4.2 Income inequality

Figure 4 relates the Thai government's data on inequality in the distribution of income per person at the household level, measured as the Gini coefficient, to data on real GDP per capita. An order 3 polynomial fitted to these data, shown in the diagram, strongly resembles Kuznets' empirical observations, as described above. It does not resemble an 'inverted-U'. Figure 5 shows these same inequality data by year, with the polynomial estimated in Figure 4 projected onto the years in which the data were observed. From Figure 5, the Gini coefficient increased gradually from 1969, at around 51%, to its highest point of 54% in 1992, declining thereafter, reaching 42% in 2023.

By international standards, these estimated levels of income inequality are high. Not surprisingly, economic inequality is an important policy issue in Thailand. The possible causes of the long-term decline in measured inequality have been an enduring puzzle for observers of the Thai economy.[11] Because our general equilibrium model, described below, does not possess a disaggregated household sector, it cannot be used to address the household distribution of income directly. But other information suggests a rough proxy that is feasible within our model: the functional distribution of income.

Figure 6 summarises data published by *Penn World Tables*, estimating the distribution of GDP at factor cost. In these data, "labour share" includes all payments to workers and "capital share" includes payments to structures, equipment and land plus the return to publicly owned capital, which is approximated. These data correlate closely with the above data on the Gini coefficient. Capital's share increased through the second half of the 1980s, reaching a maximum in 1991 or 1992, as did the Gini coefficient. Increases in measured inequality coincided with an unprecedented (and subsequently unrepeated) economic boom in Thailand (Warr 2020) that petered out in the mid-1990s, culminating in the financial crisis of 1997-1999 (Warr 1999, Vines and Warr 2003). Both measures declined after 1992, the

[11] Some scholars have questioned these data, including the decline in measured inequality since the early 1990s. The authors have no reason to disbelieve the official data.

Gini coefficient more significantly than the income share of capital. Of course, correlation is not necessarily causation. It is impossible that changes in factor income shares could fully explain changes in household income distribution. Other factors must also be involved in driving the latter. But these data do suggest that, for modelling exercises of the kind undertaken in this paper, factor income shares may be an important driver of household income distribution and an empirically useful first-order approximation to it.

5. General equilibrium model

5.1 Model structure

The analysis uses a simple, computable general equilibrium model of the Thai economy constructed for this study, that we call *Thai-lek 3,4*.[12] Most of its features are conventional for comparative-static models of this category. Its structure is based on the generic general equilibrium model ORANI-G (Horridge 2000). The production structure is summarised schematically in Figure 7. There are three production sectors: agriculture; industry; and services. This aggregation makes it possible to use available data on relevant shocks, described below. By reducing the amount of sectoral detail, this aggregation simplifies both the exposition of the model and its results.

The core database is an aggregation of the Thailand component of the 2011 release of the GTAP database (Hertel 1999). There are four primary factors of production: high-skilled labour, low-skilled labour, capital and land. Land is employed only in agriculture. The distinction between high-skilled and low-skilled labour is based on education. Low-skilled means lower primary education or less. Primary factors substitute for one another through a constant elasticity of substitution (CES) production structure. Each industry also uses intermediate goods, both imported and domestically produced, using a Leontief-type input-output structure based on the Thailand-specific data incorporated in the GTAP database.

[12] The word 'lek' is Thai for 'small' and the numbers 3 and 4 refer to the numbers of sectors and factors of production, respectively. See Warr and Yusuf (2025) for a description of an earlier version (*Thai-lek 3,3*), which aggregates high-skilled and low-skilled labour into a single category. This section relates to the 4 factor version used in this paper.

Consistent with the long-term application of the model, high-skilled labour, low-skilled labour and capital are fully mobile between all three industries but their aggregate supplies are exogenously determined. Firms employ factors and intermediate goods to minimize costs and factor markets clear, maintaining full employment. Firms behave as perfect competitors. Factor utilisation is summarised in Table 1 and the cost shares of the three industries are summarised in Table 2. It will be important for later discussion that the services sector uses both high-skilled labour and capital more intensively than either industry or agriculture. Table 3 shows that all three sectors are exposed to international trade. Consistent with the Thai data, no sector is 'non-traded'. Table 3 also summarises the elasticity assumptions, all of which are based on the GTAP model database (Hertel 1999).

There is a single household, whose demand for final commodities conforms to the Linear Expenditure System (LES) demand structure (Pollak and Wales, 1992). The three consumer goods correspond to the commodities produced by the three industries, except that consumer goods are Armington aggregates of domestically produced and imported goods (Armington 1969, Dixon, *et al.* 1992). The Armington elasticities of substitution between these two categories are shown in Table 3. It will be important for later discussion that all these elasticities are finite, as well as all export demand elasticities. The expenditure elasticities of demand for each of the three final commodities are summarised in the final column of Table 3. The value for services exceeds unity.

5.2 Model closure

Model closure separates the variables of the model into endogenous and exogenous categories. The total supply of each of the four factors is determined exogenously. The level of employment of each factor in each sector is determined endogenously (except for land, used only in agriculture), along with consumer demand, industry outputs, international trade, and all domestic factor and commodity prices. Thailand is assumed to face downwards sloping demand functions for its exports of all goods on international markets. Simulations are conducted with balanced trade (exogenous balance on current account), except when stated otherwise. This ensures that the potential economic effects of the shocks being studied do not flow to or from foreigners, through a change in the current account balance. For the same reason, real government spending and investment demand for each good are fixed exogenously. The government budget deficit is held fixed in nominal terms. This is achieved by endogenous across-the-board adjustments to the sales tax rate to restore the base level of the budgetary deficit.

5.3 Interpreting model simulations

The analysis uses a simple comparative static framework to represent structural change. But because structural change is clearly a dynamic process it is necessary to clarify the way this simplification is achieved, along with its limitations. The endogenous variables of interest are:

- Changes in the sectoral shares of output.
- Changes in the income shares of primary factors.
- Other endogenous variables, including relative prices, that help explain the above.

Endogenous and exogenous variables will be denoted by the *m*-vector Y and the *n*-vector X, respectively. Observed values of the vectors of endogenous and exogenous variables in year *t* will be denoted Y_t^0 and X_t^0, respectively. Their respective observed values in the database year of the model, year T, are thus Y_T^0 and X_T^0. Database year means the calendar year that the data and parameters contained in the database represent. The database contains information relating only to year *T*.

A model simulation is an estimated answer to the comparative-static question: Suppose, hypothetically, that the values taken by the exogenous variables in the database year had been different, in some specified proportions, from their observed values in that year. What would the resulting proportional changes in the levels of the endogenous variables have been, after a period of adjustment?

Three distinct components of this summary must be clarified.

1. The shocks. The shocks are proportional differences between: (i) the values of the exogenous variables observed in the database year, X_T^0; and (ii) counterfactual, unobserved values of these exogenous variables, also in the database year, X_T^*. The shocks are thus

$$x_T^* = (X_T^* - X_T^0) \,/\, X_T^0. \qquad (1)$$

In this notation, lower case Roman letters indicate proportional changes in variables whose levels are written in upper case Roman letters. Thus $x = dX/X$.

2. Estimated impact. Given the chosen closure, model simulations convert the above proportional shocks to the exogenous variables into estimated proportional changes in the endogenous variables. The latter are to be interpreted as differences between $\hat{Y}^{*}_{T+l}$, the estimated counterfactual values after a lag of adjustment, l, and Y^{0}_{T+l}, the observed values taken by the endogenous variables, after that same lag. The estimated proportional impact generated by the model is thus

$$\hat{y}^{*}_{T+l} = (\hat{Y}^{*}_{T+l} - Y^{0}_{T+l}) \,/\, Y^{0}_{T+l}. \tag{2}$$

In this notation, '$\widehat{\ }$' indicates that $\hat{y}^{*}_{T+l}$ is a model-derived *estimate* of the endogenous consequence of the shock and the asterisk '*' indicates that this estimate is relative to the counterfactual shocks x^{*}_{T}. The subscript *'T+l'* means that this estimated proportional change in the endogenous variable is relative to its observed value in the database year T, plus a lag – a period of adjustment. Rearranging (2), the estimated post-simulation level of variable *Y* implied by the shocks is

$$\hat{Y}^{*}_{T+l} = Y^{0}_{T+l}(1 + \hat{y}^{*}_{T+l}). \tag{3}$$

3. Lags of adjustment. The relationship between exogenous shocks and their endogenous consequences is not instantaneous but involves lags of adjustment. Nevertheless, the class of models employed here is comparative-static and time itself is not formally represented.[13] The true lags are unknown, but lags of adjustment are relevant for our study because we are focused on longer-run adjustment processes. The assumed lags are judgments on the part of the researcher, based partly on the choice of model closure, but the period of adjustment is not explicit and is always approximate. In our empirical analysis, we take this lag to be three years.

Observed values of *X* follow the path between the value in year *T - k*, prior to the database year, denoted X^{0}_{T-k}, and the value in the database year, X^{0}_{T}. The hypothetical value X^{*}_{T} is not observed. An imagined counterfactual story of some kind underlies it. This story could

[13] Within this comparative-static modelling framework, the treatment of adjustment lags is implicit, requiring judgment. Some impacts may be instantaneous, but short-run, medium-run and long-run adjustments can be distinguished, imperfectly, through model closure. For example, if short-run adjustments are being considered, capital stocks in each sector might be held fixed (exogenous rather than endogenous). For longer-run adjustment periods, as in this study, the reverse closure assignment is appropriate.

include a narrative about how historical data prior to year T might, hypothetically, have differed from their observed values, speculation about the future, following year T, a combination of both, data from some other country, or purely imagined assumptions involving none of these elements. But it is important that this narrative story, historical or otherwise, supporting the counterfactual value X_T^*, is relevant for the simulations only in so far as it affects the numerical value of X_T^*. That is, the supposed time path of X_t^* between time $T - k$ and T may be part of the motivating story, but it plays no part in the analysis except for the resulting level of X_T^*. That is the essential difference between the comparative-static approach of this paper and a truly dynamic model. It is also a limitation of the former.

The available data on factor supplies and total factor productivity commence in 1990. Year $T - k$ is thus 1990. Year T is 2011 because that was the latest GTAP available to the authors. Year $T + l$ is thus 2014, given the assumed lag of three years.

6. The shocks

The construction of the shocks is more complex than the stylised representation in equation (1) above, but it follows the same principles.[14] Table 4 summarises the shocks used in the simulations. The discussion below explains them.

6.1 Explanator (a): Factor supply differences

Consider the following conceptual experiment. Holding levels of factor productivity in each sector constant, imagine expanding the aggregate supplies of all factors of production at the same uniform rate. As a result of this counterfactual experiment, the aggregate PPF would expand uniformly – with no change of shape. *Differences* between the growth rates of factors, rather than the absolute levels of factor growth, would potentially drive changes in the shape of the PPF. It was these differences between factor growth rates that Rybczynski (1955) analysed.

Table 4 (columns [1] and [2]) summarises the growth of the aggregate stocks of high-skilled labour, low-skilled labour, capital and land for Thailand over the period 1990 to 2011.

[14] As the subsequent discussion below will show, our analytical treatment of consumer demand parameters is necessarily different from that of the four other sets of exogenous variables summarised above. Behavioural parameters are not exogenous variables in the same sense as the variables considered in the other four shocks.

According to the Thai government study producing these estimates, land is assumed to be used only in agriculture, as in our model. Consider hypothetical growth paths of the aggregate stocks of these factors, covering the period 1990 to 2011, in which the factors each grow at the same annual growth rate *r*, resulting in the same level of real GDP in 2011 as was observed in that year. Now consider the counterfactual levels in 2011 of the total supplies of factors that are implied by this exercise. The proportional differences between these counterfactual 2011 factor supply levels and the observed levels in 2011 are the shocks represented by equation (1).

We now construct a counterfactual in which we take away the observed sectoral *differences* in the growth rates of primary factors (high-skilled labour, low-skilled labour and capital, but not land), by requiring them to grow at the same annual rate *r*, where *r* generates the observed level of real GDP in 2011.[15] The difference between (i) the observed sectoral shares in 2014 (not 2011; see the discussion of lags above) and (ii) the counterfactual shares estimated for 2014 through model simulation, is then attributed to the *differences* in the growth rates of these three primary factors. The (exogenous) shock is given by equation (1) and the estimated impact that this explanator has on (endogenous) sectoral shares is thus (i) – (ii), or from equation (3),

$$Y_{T+l}^{0} - \hat{Y}_{T+l}^{*} = - \hat{y}_{T+l}^{*} Y_{T+l}^{0}. \tag{4}$$

6.2 Explanator (b): Factor productivity differences

Table 4 now shows the estimated rates of TFP growth in agriculture, industry and services, between 1990 and 2011, drawing on the same Thai government study as the factor supply estimates described above. Similar to the exercise for factor supplies, we conduct a counterfactual simulation in which TFP growth rates are constrained to increase at the same constant annual rates *s* in agriculture, industry and services between 1990 and 2011, again producing the same level of real GDP as was observed in 2011. The counterfactual levels of TFP in 2011 are then estimated in the same manner as described above for factor supplies.

[15] Agricultural land is excluded from the factors of production whose supplies are constrained to increase at the same rate, as described above. The supply of land remains as specified in the data, but the other three primary factors are treated as above. Land is excluded because significant expansion of the stock of agricultural land would be impossible. A counterfactual involving it would be overly artificial for the purposes of this study.

Again, the logic is: we take away the observed sectoral *differences* in TFP growth, by requiring their growth rates to be equal, subject to producing the observed level of GDP in 2011. Consider the levels in 2011 of TFP in agriculture, industry and services implied by this exercise. The proportional differences between these counterfactual values and the observed levels in 2011 are the shocks represented in equation (1). The difference between the observed structural change and that estimated is then attributed to the *differences* in TFP growth rates, as in equation (4).

6.3 Explanator (c): Consumer expenditure effect

The Engel's law explanation for structural change has two components: (i) non-unitary expenditure elasticities of demand that we call non-homothetic demand; and (ii) an increase in final household expenditure accompanying economic growth. The expenditure elasticities assumed in the model are summarised in Table 3, column [7]. The percentage increase in real consumption from 1990 to 2011 was 61.8 per cent. The counterfactual analysis removes this increase in consumption expenditure by separating the change in household expenditure from changes in GDP and its other components. Consider the familiar demand-side national accounting identity, where all variables are defined in real terms (GDP deflator), C is household consumption, I is total investment, G is government expenditure and $X - M$ is the trade balance. Rearranging it,

$$C = GDP - I - G - (X - M). \qquad (5)$$

Given our model closure (see above), real GDP is determined by technology and the aggregate supply of resources, all of which are exogenous. Each of the other terms on the RHS of (5) is also exogenous, including the trade balance, $(X - M)$. In all simulations discussed above, the change in the trade balance was exogenously zero. The shock to consumer expenditure was implemented by changing the trade balance exogenously by an amount sufficient to reduce real consumption expenditure in 2011 to its 1990 level.[16] That required change in the trade balance was found through an iterative series of simulations called 'grid search'. The exogenous shock applied in the simulation is this required change in the trade balance.

[16] The required percentage change in the 2011 level of real consumption was $100(100 - 161.8)/161.8 = -38.2\%$.

This counterfactual exercise of changing the trade balance can be understood as eliminating the increase in household expenditure that occurred between 1990 and 2011 by exogenously transferring to foreigners enough revenue to keep real household expenditure at its 1990 level, leaving the supply side of the economy unaffected. Historically, the large increase in observed real consumption, combined with non-homothetic expenditure elasticities of demand, induced changes in relative commodity prices that presumably influenced structural change. The consumer expenditure shock eliminates those demand-induced relative price changes, by removing the underlying increase of household expenditure, leaving all other determinants of structural change unaffected. The difference between the actual structural change and the counterfactual change estimated through this simulation is then attributed to the observed increase in household expenditure, combined with non-homothetic demand.

7. Results: Structural change

Figure 6 provides a convenient summary. It is suggested that readers focus initially on this diagram. Detailed results are provided in Table 5. Actual value-added shares are summarised in Panel 1 of Figure 6 and the first three columns of Table 5. The contraction of services over the period covered was somewhat atypical of the six decades shown in Figure 2. It is nevertheless reasonable to expect that the model should roughly predict this observed change.

7.1 Summary of results

Explanator (a): Factor supply differences

The growth rates of actual factor supplies differed significantly from one another (Table 4). The physical capital stock grew fastest and high-skilled labour grew faster than low-skilled labour. The simulated structural change outcomes are summarised in Panel 2 of Figure 6. The impacts are smaller than might have been expected, given Rybczynski's famous magnification result. The simulated contraction of agriculture is only one fourth of the observed contraction. The composition of the simulated structural change also differs from that expected in that industry, the most capital-intensive sector, contracts while services expands. The fact that factor supplies grew at different rates does not, by itself, explain the observed structural change well.

Explanator (b): Factor productivity differences

The data summarised in Table 4 show that actual productivity growth was largest in industry, followed by services and then agriculture, the latter two negative. The simulation results, summarised in Panel 3 of Figure 6, indicate that these differences imply a reduction in agriculture's value-added share of 2.14 per cent, marginally smaller than the actual contraction, along with an expansion of industry and contraction of services, qualitatively similar to but larger than the observed changes. According to these results, differences in productivity growth explain most of the observed structural change.

Now consider the impact of shocks (a) and (b) jointly, shown in Panel 4 of Figure 6. These two supply-side shocks explain the actual structural change very closely.

Explanator (c): Consumer expenditure effect

The expenditure shock predicts a very small contraction of agriculture, and substantial changes in the shares of industry and services, but in the opposite directions from those observed. According to these findings, Engel's law, by itself, is a poor predictor of structural change.

Finally, Panel 6 of Figure 6 summarises the structural effects of shocks (a), (b) and (c) jointly. The contraction of agriculture is predicted roughly correctly, but the predicted changes in the shares of industry and services have incorrect signs. In summary, comparing Panel 4 with Panel 6, the former explains structural change well but allowing for expenditure effects such as Engel's law worsens the explanation. The demand system has an effect, but not in the direction of the actual structural changes.

7.2 Explaining the results

Endogenous changes in commodity prices explain most of the above findings. The simulated domestic price changes reflect the structural and parametric assumptions of the *Thai-lek 3,4* model. In particular, the finite Armington and export demand elasticities (columns [3] and [4] of Table 3) imply considerable domestic price flexibility. In contrast, within the standard Heckscher-Ohlin-Samuelson (HOS) small country trade theoretic model, as used by

Rybczynski, these elasticities are each infinite in absolute value (Jones 1965). In that model, domestically produced goods are perfect substitutes for imported goods and export demands are infinitely elastic. Domestic prices are fully determined by international prices and cannot respond to domestic shocks. This difference in assumptions about price determination explains the difference between the results expected under the HOS model and our results.

Consider the implications of arbitrarily increasing the assumed values of these two sets of elasticity parameters. Table 6 shows the results from repeating the simulations summarised in Table 5 and Figure 6, but using assumed values of each Armington and export demand elasticity shown in columns [3] and [4] of Table 3 arbitrarily multiplied by a factor of 40.[17] All other assumptions are unchanged. Using these experimental parameters, the estimated structural changes are radically different from both the observed (actual) changes and from the estimated (counterfactual) changes simulated using the base parameters (Table 5). The structural effects of the two supply-side shocks (a) and (b) are much larger than those obtained with the base parameters, while the structural effects of the consumer expenditure shock (c) are much smaller.

Table 7 shows the reason for these results. The table shows changes in relative prices, normalised on the price of industry.[18] The upper panel ('Base parameters') shows changes in relative domestic prices from the base simulations summarised in Figure 6 and Table 5. Consider the supply-side shocks (a) and (b) first. Relative domestic prices move endogenously *against* the structural changes caused by these shocks, reducing the magnitude of the structural changes that would otherwise occur if domestic prices did not respond. Elasticity assumptions that permit domestic price flexibility makes these opposing price changes possible. This is why the resulting structural change is smaller than might be expected intuitively by readers familiar with the HOS-Rybczynski model. The lower panel ('Experimental parameters') shows that much larger values of these two sets of elasticity parameters result in much smaller domestic price responses. Smaller opposing domestic price responses means larger structural change effects.

[17] Infinite values of these elasticities caused the model to be unsolvable. The multiple of 40 is used to show the effect of these elasticities being 'large'.
[18] That is, the prices of agriculture and services are expressed relative to the price of industry. The level of the industry price is unity and its percentage change is zero, by construction.

The expenditure shock (c) produces smaller structural change effects under the experimental parameters than under the base parameters, and for the same reason as above. This demand-side explanator impacts on the supply side of the economy only through changes in the relative prices faced by producers. If domestic prices were tied to exogenous international prices, as in the HOS-Rybczynski model, Engel's law would be irrelevant.[19] When these price changes are possible but muted, as with the experimental parameters, the structural change effects are also muted.

Two further explanatory factors are important. First, simulated changes in the sectoral share of agriculture are generally smaller than those in industry and services. One factor of production, land, is used solely in that sector. The existence of this sector-specific factor moderates the labour and capital movements out of agriculture that would occur if all factors were inter-sectorally mobile. Because this sector-specific factor remains constant, as labour and capital exit agriculture their marginal products increase rapidly, restraining their movement out of agriculture.

Second, in the case of services, the expenditure shock (c) increases the share of services, reflecting the relative price consequences of that commodity's high expenditure elasticity of demand (Figure 7, Base parameters, column [3]). But because all aggregate factor supplies are fixed in that simulation, services can obtain the resources required for its expansion only from agriculture and industry. They come primarily from industry, for two reasons. First, because of the fixity of land in agriculture, as just explained. Second, recall from Table 2 that services is the sector that uses capital and high-skilled labour most intensively, and agriculture uses these factors the least intensively. When services expands, the capital and high-skilled labour it requires must come primarily from industry. Thus services expands and industry contracts (Panel 5 of Figure 6 and column [5], explanator (c), of Table 5) – the opposite of the observed structural changes.

[19] Anderson (1987) also makes this point. Anderson introduces a non-traded good (services) into the HOS model, making possible some domestic price adjustment in response to Engel's law. The discussion attributes structural change to the existence of this non-traded good, reasonably assuming it to have an income elasticity of demand above unity. This account predicts that as incomes increase the price of services will increase relative to the prices of internationally traded agricultural and industrial goods, the relative domestic prices of which are determined by their fixed international prices. Services' expansion requires labour and capital, which must come from agriculture and industry. Contraction of agriculture can release labour, but insufficient capital for services' requirements, so this model predicts that services will expand and both agriculture and industry contract.

In summary, supply-side explanators, especially sectoral differences in total productivity growth, dominate the resulting structural change. Agriculture contracted mainly because of low productivity growth in that sector, relative to other sectors. The share of industry grew the most, mainly because of high productivity growth in that sector.

8. Results: Income distribution

We now wish to test the null hypothesis that structural change, on the one hand, and factor income shares, on the other, have similar explanators. Estimated levels of factor income shares and changes in them are reported in Table 8, using the 'base parameter' simulation results summarised in Table 5. We wish to compare these results with the observed factor income shares for 'capital' and 'labour' from *Penn World Tables* (Figure 6). Table 9 now aggregates the results from Table 8 to match these two categories: income shares for capital and land are combined in a single category and shares for high-skilled and low-skilled labour are similarly combined.

According to the *Penn World Tables* data, between 1990 and 2014 actual factor income shares moved in favour of aggregate labour (+5.3%) and against capital plus land (-5.3), a finding that is consistent with the observed decline in the Gini coefficient from Figure 5 (51% to 45%) over that period. Table 9 shows that in the simulation results corresponding to each of our explanators, (a), (b) and (c) the opposite is predicted. The drivers that explain structural change most effectively, the supply-side explanators (a) and (b), predict changes in factor income shares opposite in sign to the changes observed.

Other forces, not captured by our analysis, must be the principal drivers of changes in factor income shares, outweighing the impacts of the explanators we have identified in our analysis of structural change. The principal drivers of structural change and factor income shares must be very different. This finding means that unless the drivers of structural change identified in this study were, for some reason, highly correlated with the (unknown) drivers of factor income shares, no stable relationship should be expected between these two sets of endogenous outcomes.

9. Conclusions

Structural change is a fundamental feature of economic development (Clark 1957, Chenery and Syrquin 1975, Timmer 2014, Monga and Lin 2019). It could arise from changes in technology and/or resources, which change the shape of the aggregate production possibilities frontier, or through demand-induced changes in relative output prices, causing shifts around the frontier, or both. This study uses a simple general equilibrium modelling approach to discriminate between these economic forces, using data for Thailand. The objective was first to disentangle the contributions these various potential drivers make to structural change. The principal finding is that structural change was driven primarily by differences between sectors in their rates of productivity growth. Differences between the growth rates of factors of production played a secondary role. The combination of these two supply-side drivers explained the observed structural change well. Demand-side forces such as Engel's law performed poorly as explanators of the observed data.

A second objective was to extend this analysis to incorporate changes in the functional distribution of income, motivated by their potential relevance for household-level inequality. Structural change and the functional distribution of income can each be considered the endogenous outcomes of general equilibrium economic processes. They are necessarily related, but neither could reasonably be considered a direct cause of the other. Nevertheless, if the exogenous variables driving them were similar, co-movement in these two sets of outcomes might be expected.

The results of this study do not support this hypothesis. Based on the simulation results, the economic drivers of structural change, on the one hand, and the functional distribution of income, on the other, are very different. We should not necessarily expect stable empirical relationships to exist between them. There could be historical periods when these two sets of endogenous outcomes move together, and periods when they diverge, as Kuznets rightly said.

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Table 1. Primary factor utilisation (cost basis, 2011)

(Units: per cent of initial total employment of factor)

	High-skilled labour	Low-skilled labour	Capital	Land
Agriculture	0.2	27.8	1.6	100
Industry	16.0	47.3	37.3	0
Services	83.8	24.9	61.1	0
Total	100	100	100	100

Note: The above calculations describe the database of the CGE model, which relates to 2011. The calculation of labour allocation is based on costs, not number of workers. Wages in agriculture are lower than elsewhere. When the percentage allocation of total labour is based on number of workers it is: agriculture 38.7; industry 14.5; services 46.7.
Source: Authors' calculations from GTAP 2011 database, Thailand, as described in Hertel (1999).

Table 2. Industry cost shares

(Units: per cent total primary factor cost)

	High-skilled labour	Low-skilled labour	Capital	Land	Intermediate inputs		Commodity Taxes	Total
					Domestic	Imported		
Agriculture	0.2	22.3	6.0	28.2	34.3	8.0	0.9	100
Industry	2.3	4.0	14.7	0.6	41.9	34.5	1.8	100
Services	17.2	2.9	33.8	0	38.3	6.3	1.5.	100
Total	8.0	4.7	21.7	2.0	40.0	21.9	1.6	100

Source: Authors' calculations from GTAP 2011 database, Thailand, as described in Hertel (1999).

Table 3. Trade shares and principal elasticity assumptions

Sector / commodity	Trade shares (%)		Elasticity parameters				
	Import	Export	Armington elasticity of substitution: imports / domestic goods	Export demand elasticity	Elasticity of substitution: primary factors	Elasticity of substitution: high-skilled / low-skilled labour	Expenditure elasticity of demand
Agriculture / food	10.6	7.5	2.4	4.9	0.25	0.5	0.414
Industry / manufactured goods	46.4	45.3	3.5	7.7	1.03	0.5	0.823
Services	7.9	10.0	1.9	3.9	1.37	0.5	1.197
[Column number]	[1]	[2]	[3]	[4]	[5]	[6]	[7]

Note: Import share means imports / domestic demand. Export share means exports / domestic production. Elasticity of factor substitution means substitution among primary factors. In addition, low-skilled and high-skilled labour are nested substitutes in each sector with an elasticity of substitution of 0.5.
Source: Authors' calculations from GTAP 2011 database, Thailand, as explained in Hertel (1999).

Table 4. Shocks to exogenous variables

Variable	Units	Actual level 1990 (X^0_{1990})	Actual level 2011 (X^0_{2011})	Counterfactual level 2011 (X^*_{2011})	Shock: (%) $100(X^*_{2011} - X^0_{2011})$ $/(X^0_{2011}]$
Explanator (a): Factor supply differences					
High-skilled labour	Thousands	6,556	12,080	14,584	20.73
Low-skilled labour	Thousands	23,379	26,357	50,945	93.29
Capital	Index: 1990 = 100	100	271.4	222.01	-18.02
Land	Index: 1990 = 100	100	115.10	115.10	0
Explanator (b): Factor productivity differences					
Agriculture	Index: 1990 = 100	100	64.4	83.92	30.34
Industry	Index: 1990 = 100	100	139.6	83.92	-39.89
Services	Index: 1990 = 100	100	71.8	83.92	16.86
[Column number]		[1]	[2]	[3]	[4] = 100([3]-[2])/[2]

Note: Each of the shocks shown above *removes* the effect of one the explanatory variables concerned, leaving all other exogenous variables unchanged.

Source: Authors' calculations, using data from the Thai government's National Economic and Social Development Council, available at: https://www.nesdc.go.th/nesdb_en/article_attach/EN-Capital%20Stock%202023.pdf

Table 5. Results: Value-added shares (VAS), per cent, base parameters

Variable	Actual level of VAS, 1990 (Y^0_{1990})	Actual level of VAS, 2014 (Y^0_{2014})	Actual change in VAS, 1990 to 2014 ($Y^0_{2014} - Y^0_{1990}$)	Counterfactual level of VAS, 2014 (Y^*_{2014})	Estimated impact of explanator on VAS ($Y^0_{2014} - Y^*_{2014}$)
Explanator (a): Factor supply difference					
Agriculture VAS (%)	9.91	7.09	-2.82	7.74	-0.65
Industry VAS (%)	28.42	34.20	5.78	35.18	-0.98
Services VAS (%)	61.67	58.71	-2.96	57.08	1.63
Explanator (b): Factor productivity difference					
Agriculture VAS (%)	9.91	7.09	-2.82	9.23	-2.14
Industry VAS (%)	28.42	34.20	5.78	27.43	6.77
Services VAS (%)	61.67	58.71	-2.96	63.34	-4.63
Explanator (c): Consumer expenditure effect					
Agriculture VAS (%)	9.91	7.09	-2.82	7.17	-0.08
Industry VAS (%)	28.42	34.20	5.78	37.93	-3.73
Services VAS (%)	61.67	58.71	-2.96	54.90	3.81
[Column number]	[1]	[2]	[3] = [2] - [1]	[4]	[5] = [2] - [4]

Note: 'Actual value-added shares' means those observed in the data. 'Counterfactual value-added shares' means those estimated using the simulation model. 'Base parameters' means that the simulations use the parameters shown in columns [3] to [7] of Table 3.

Source: Authors' calculations from simulation results.

Table 6. Sensitivity results: Value-added shares (VAS), per cent, experimental parameters

Variable	Actual level of VAS, 1990 (Y^0_{1990})	Actual level of VAS, 2014 (Y^0_{2014})	Actual change in VAS, 1990 to 2014 ($Y^0_{2014} - Y^0_{1990}$)	Counterfactual level of VAS, 2014 (Y^*_{2014})	Estimated impact of explanator on VAS ($Y^0_{2014} - Y^*_{2014}$)
Explanator (a): Factor supply difference					
Agriculture VAS (%)	9.91	7.09	-2.82	7.83	-0.74
Industry VAS (%)	28.42	34.20	5.78	45.03	-10.83
Services VAS (%)	61.67	58.71	-2.96	47.14	11.57
Explanator (b): Factor productivity difference					
Agriculture VAS (%)	9.91	7.09	-2.82	9.69	-2.60
Industry VAS (%)	28.42	34.20	5.78	0.85	33.35
Services VAS (%)	61.67	58.71	-2.96	89.46	-30.75
Explanator (c): Consumer expenditure effect					
Agriculture VAS (%)	9.91	7.09	-2.82	7.07	0.02
Industry VAS (%)	28.42	34.20	5.78	35.21	-1.01
Services VAS (%)	61.67	58.71	-2.96	57.73	0.98
[Column number]	[1]	[2]	[3] = [2] - [1]	[4]	[5] = [2] - [4]

Note: 'Experimental parameters' means that the simulations use the parameters shown in Table 2 except for Armington elasticities of substitution and export demand elasticities, each of which is set at 40 times the values shown in Table 3.

Source: Authors' calculations from simulation results.

Table 7. Results: Changes in domestic relative prices (DRP), per cent change

Variable	Explanator (a): Factor supply shock	Explanator (b): Factor productivity shock	Explanator (c): Expenditure shock
Domestic relative price – base parameters			
Agriculture DRP (% change)	8.51	33.16	-4.67
Industry DRP (% change)	0	0	0
Services DRP (% change)	-6.55	19.60	3.85
Domestic relative price – experimental parameters			
Agriculture DRP (% change)	-0.42	4.48	0.03
Industry DRP (% change)	0	0	0
Services DRP (% change)	-2.16	4.45	0.34
[Column number]	[1]	[2]	[3]

Note: 'Base parameters' means that the simulations use the parameters shown in Table 3. 'Experimental parameters' means that the simulations use the parameters shown in Table 3 except for Armington elasticities of substitution and export demand elasticities, each of which is set at 40 times the values shown in columns [3] and [4], respectively, of Table 3. Prices in the table are normalized relative to the price of industry, the level of which remains at unity, so its percentage change is zero.

Source: Authors' calculations from simulation results.

Table 8. Results: Simulated factor income shares (FIS), per cent

Variable	Observed level of FIS, 2014 (Y^0_{2014})	Counterfactual level of FIS, 2014 (Y^*_{2014})	Estimated impact of explanator on FIS ($Y^0_{2014} - Y^*_{2014}$)
Explanator (a): Factor supply difference			
High-skilled labour FIS (%)	22.07	24.07	-2.00
Low-skilled labour FIS (%)	12.91	14.82	-1.91
Capital FIS (%)	59.54	55.46	4.08
Land FIS (%)	5.48	5.65	-0.17
Explanator (b): Factor productivity difference			
High-skilled labour FIS (%)	22.07	21.23	0.84
Low-skilled labour FIS (%)	12.91	13.97	-1.07
Capital FIS (%)	59.54	60.79	-1.25
Land FIS (%)	5.48	4.00	1.48
Explanator (c): Consumer expenditure effect			
High-skilled labour FIS (%)	22.07	20.58	-1.49
Low-skilled labour FIS (%)	12.91	14.19	1.28
Capital FIS (%)	59.54	58.83	-0.71
Land FIS (%)	5.48	6.40	0.92
[Column number]	[1]	[2]	[3] = [2] - [1]

Source: Authors' calculations from simulation results.

Table 9. Results: Factor income shares by factor (FIS), per cent

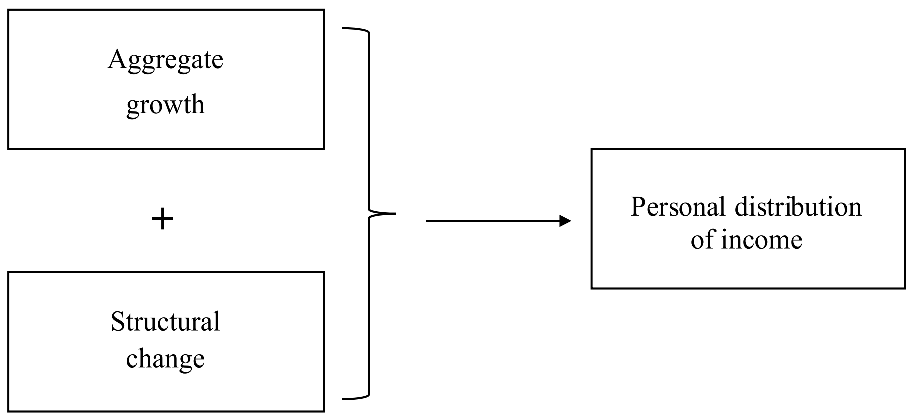
Variable	Actual change in FIS (1990 to 2024)	Observed level of FIS, 2014 (Y^0_{2014})	Counterfactual level of FIS, 2014 (Y^*_{2014})	Estimated impact of explanator ($Y^0_{2014} - Y^*_{2014}$)
Explanator (a): Factor supply difference				
High-skilled + low-skilled labour FIS (%)	5.3	34.98	38.89	-3.91
Capital + land FIS (%)	-5.3	65.02	61.11	3.91
Explanator (b): Factor productivity difference				
High-skilled + low-skilled labour FIS (%)	5.3	34.98	35.20	-0.23
Capital + land FIS (%)	-5.3	65.02	64.79	0.23
Explanators (a) and (b) jointly				
High-skilled + low-skilled labour FIS (%)	5.3	34.98	39.12	-4.14
Capital + land FIS (%)	-5.3	65.02	60.88	4.14
Explanator (c): Consumer expenditure effect				
High-skilled + low-skilled labour FIS (%)	5.3	34.98	35.19	-0.21
Capital + land FIS (%)	-5.3	65.02	64.81	0.21
Explanators (a), (b) and (c) jointly				
High-skilled + low-skilled labour FIS (%)	5.3	34.98	39.53	-4.55
Capital + land FIS (%)	-5.3	65.02	60.47	4.55
[Column number]	[1]	[2]	[3]	[4] = [2] - [3]

Note: 'Actual change in FIS' (Column [1]) means the change estimated in *Penn World Tables*, version 9.1, available at: https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1. According to these data (see Figure 6), the share of labour (high-skilled plus low-skilled) was 35.8 per cent in 1990 and 41.1 per cent in 2014, an increase of 5.3 per cent. The change in the share of 'capital' is necessarily equal and opposite in sign. 'Observed level of FIS' (Column [2]) means the factor share implied by the model's database. 'Counterfactual level of FIS' (Column [3]) means the factor share estimated in the model simulations, without the explanator specified.

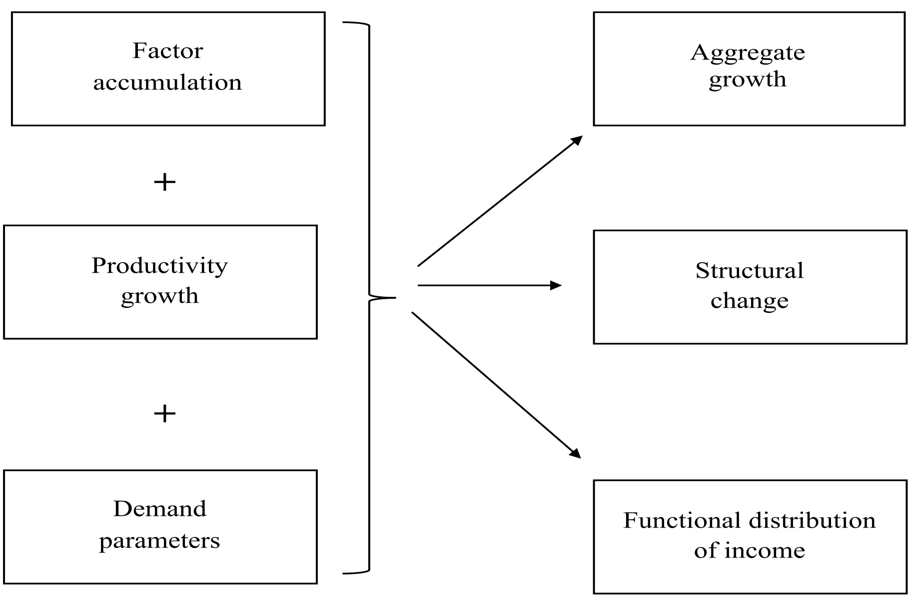
Source: Authors' calculations from simulation results.

Figure 1. Analytical framework

Panel a: Kuznets (1955)

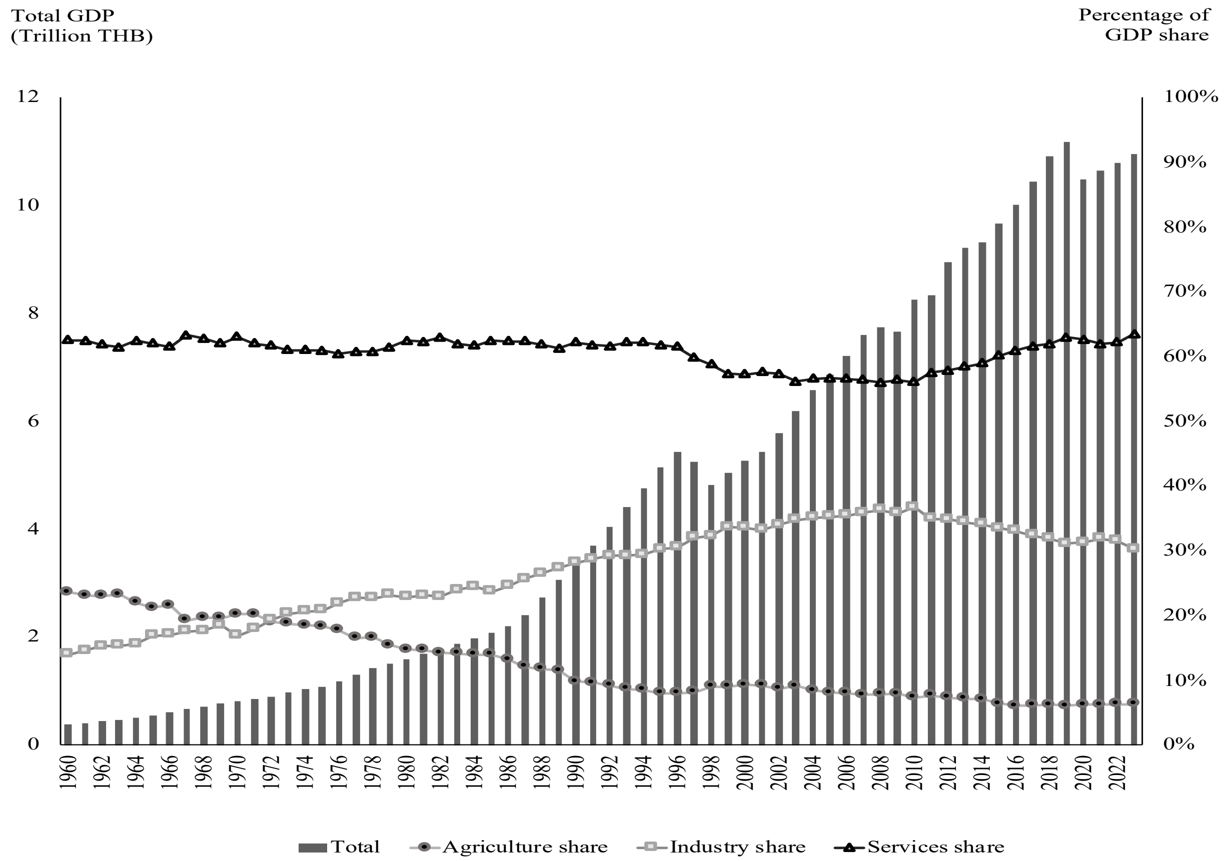


Panel b: This paper



Source: Authors' construction.

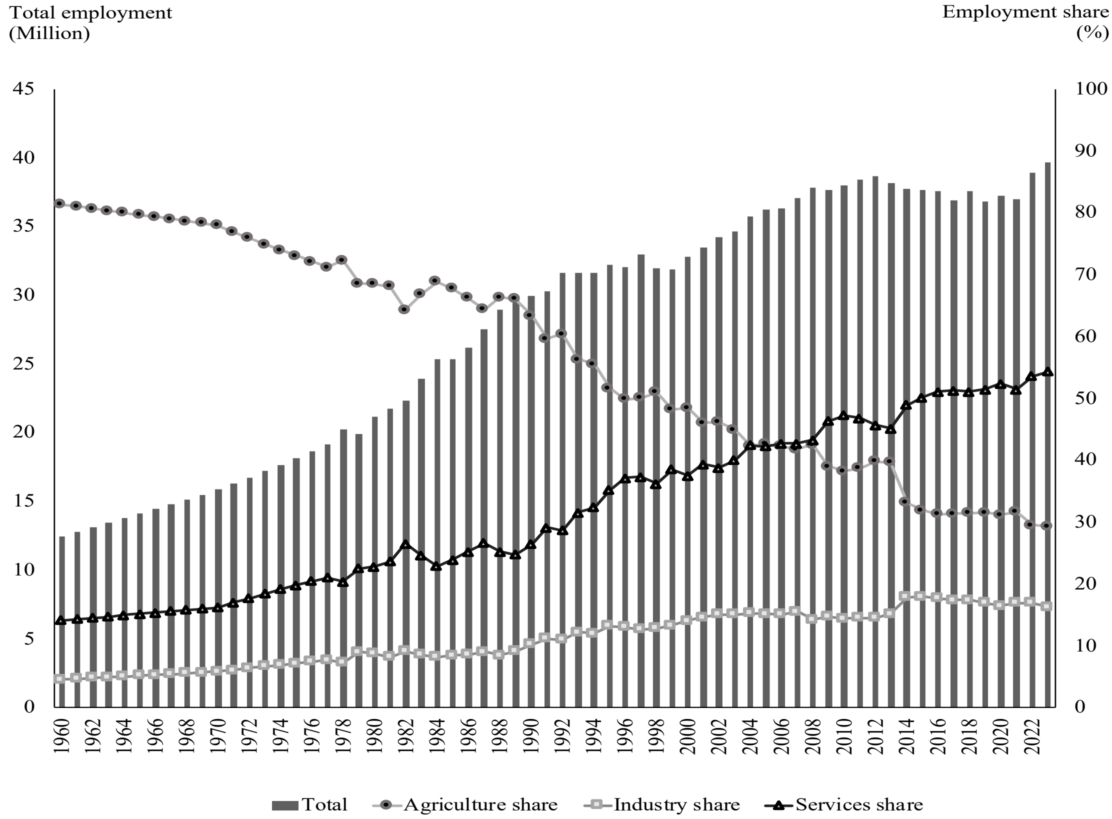
Figure 2. Thailand: Structural change, 1960 to 2023 – Value-added



Note: The LHS axis shows total real GDP in trillions (10^{12}) of Thai baht at constant 2002 prices. The RHS axis shows sectoral value-added shares of GDP in per cent.

Source: Authors' calculations, using data from National Economic and Social Development Council, Bangkok. Available at: https://www.nesdc.go.th/nesdb_en/ewt_news.php?nid=4509&filename=national_account

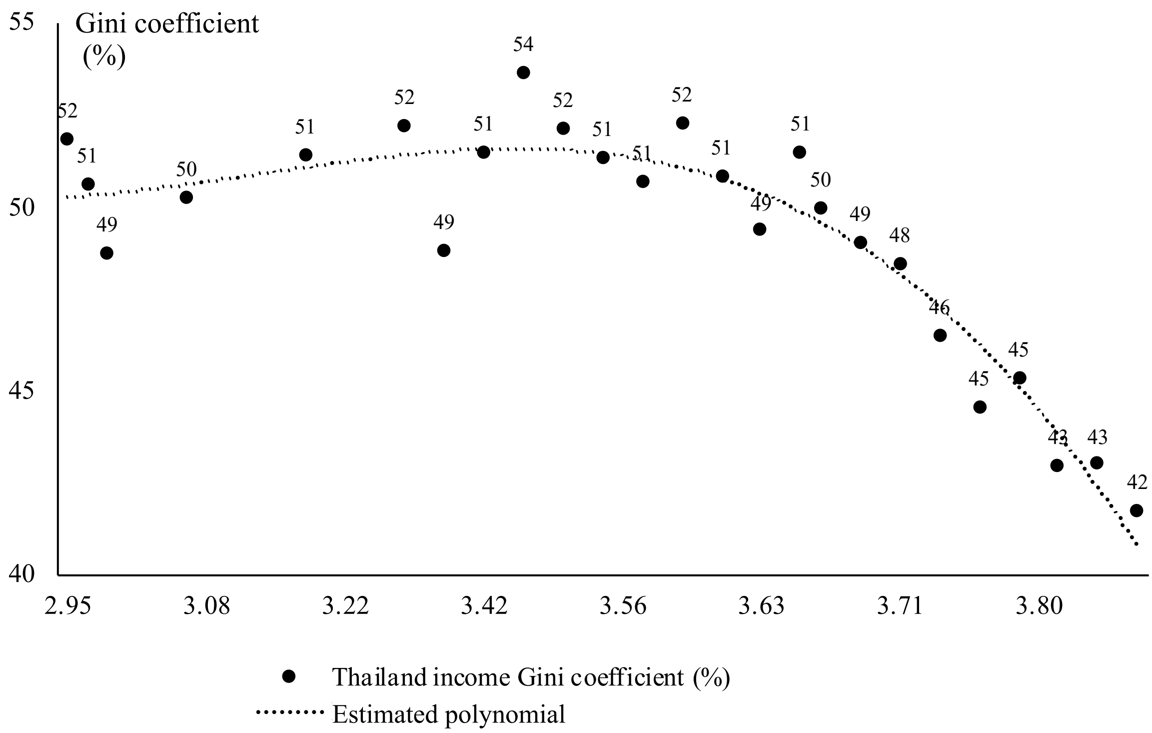
Figure 3. Thailand: Structural change, 1960 to 2023 – Employment



Note: The LHS axis is total employment in millions. The RHS axis is sectoral employment shares in per cent.

Source: Authors' calculations, using data from National Statistical Office, Bangkok, Labour Force Survey, available at: https://www.nso.go.th/nsoweb/nso/survey_detail/9u?set_lang=en

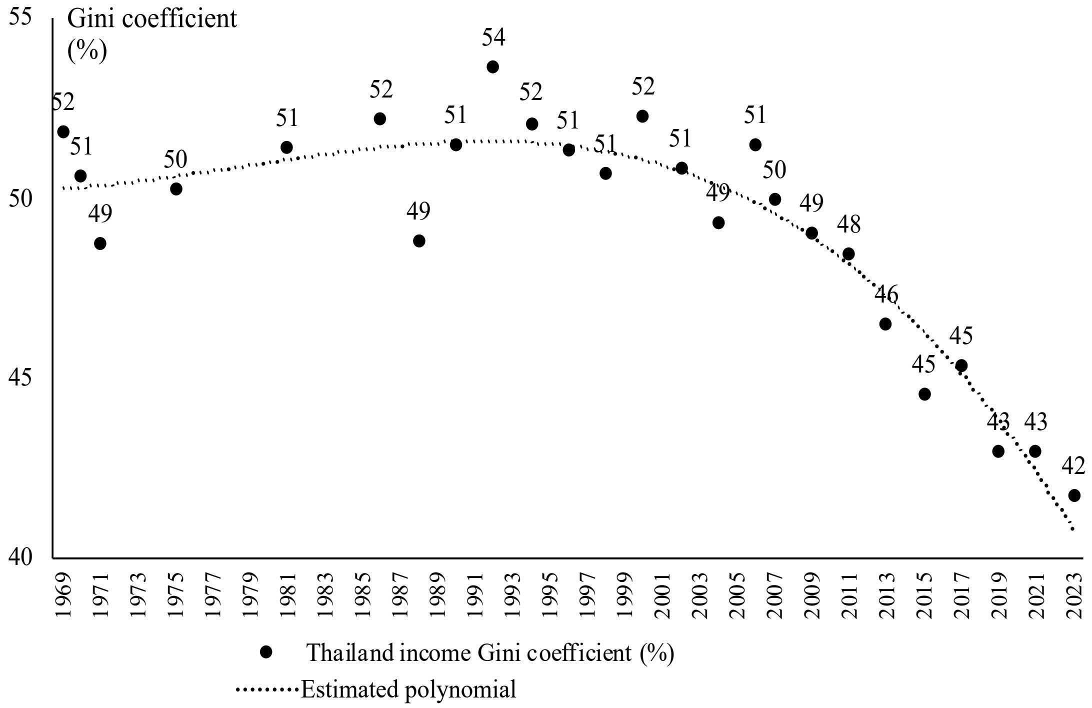
Figure 4. Thailand: Gini coefficient (per cent) and income per capita, 1969 to 2023



Note: The vertical axis starts at a Gini index of 40%, not zero. The horizontal axis is the is the logarithm (base 10) of real GDP per capita in 2002 prices. The large dots are the reported values of the Gini coefficient in per cent. The small dots are the estimated values of the fitted polynomial: $Gini = -0.0002x^3 + 0.005x^2 + 0.0254x + 50.234$, where x is the variable on the horizontal axis.

Source: Authors' calculations using data from National Economic and Social Development Council, Bangkok. Available at:
https://www.nso.go.th/nsoweb/nso/statistics_and_indicators?order=&search=gini&impt_side=&impt_branch=309&impt_group=0&impt_subgroup=&year=&announcement_date=

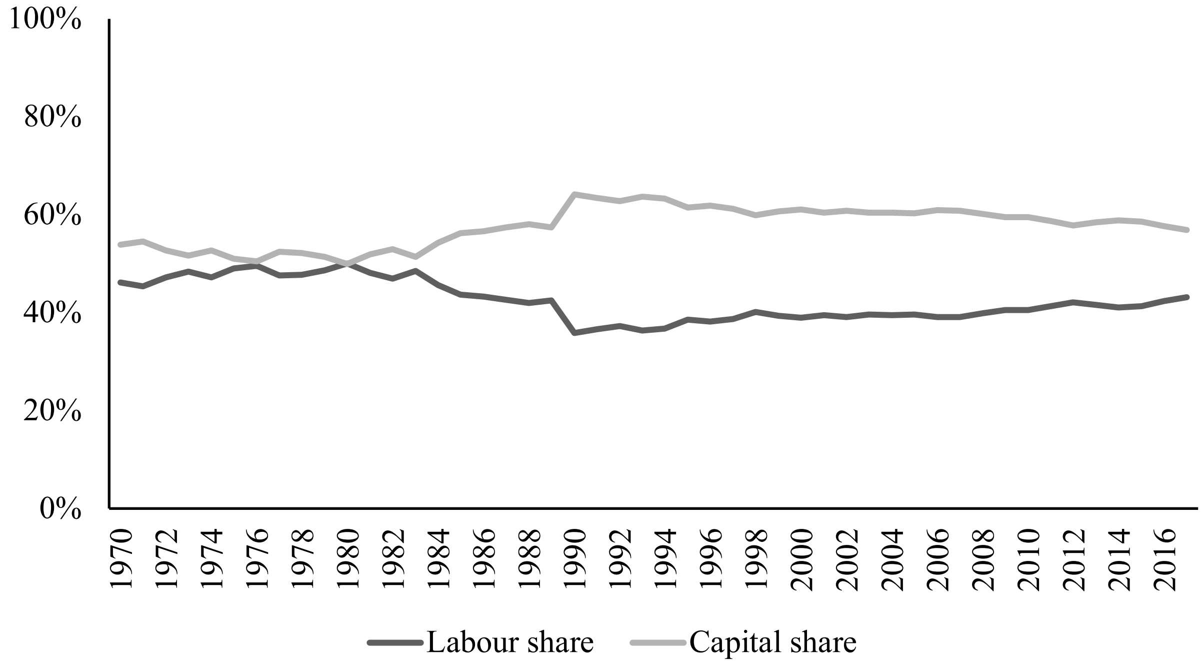
Figure 5. Thailand: Gini coefficient (per cent), 1969 to 2023



Note: The vertical axis starts at a Gini index of 40%, not zero. The large and small dots are as in Figure 4. The figure projects the polynomial estimated in that figure to the years in which the data were observed.

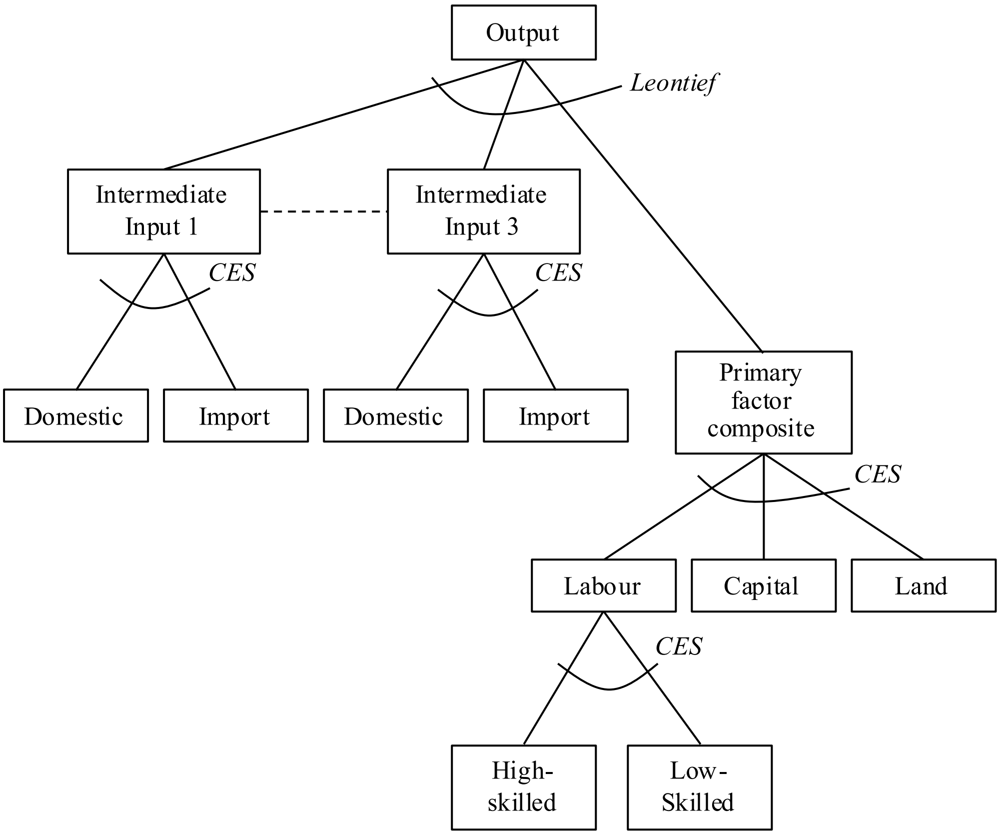
Source: Authors' calculations using data from National Economic and Social Development Council, Bangkok. Available at:
https://www.nso.go.th/nsoweb/nso/statistics_and_indicators?order=&search=gini&impt_side=&impt_branch=309&impt_group=0&impt_subgroup=&year=&announcement_date=

Figure 6. Share of capital and labour in GDP at factor cost, 1970 to 2017 (per cent)



Note: In these data, income from capital includes income from land.
Source: Authors' calculations from *Penn World Tables* version 9.1. Available at:
https://www.rug.nl/ggdc/productivity/pwt/pwt-releases/pwt9.1

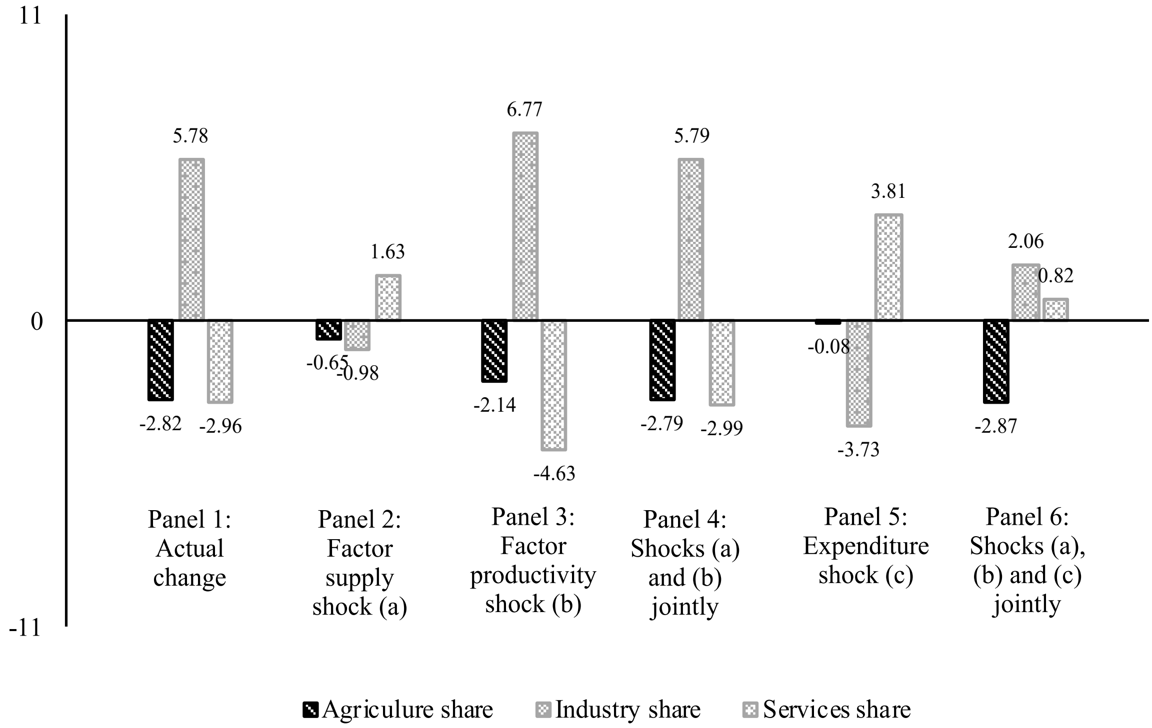
Figure 7. Production structure for each sector



Note: Industry and services use the primary factors high-skilled labour, low-skilled labour and capital. Agriculture uses the same factors plus land. All three sectors also use intermediate goods, which are CES (Armington) aggregates of domestically produced and imported intermediate goods.

Source: Authors' construction.

Figure 8. Actual and simulated changes in value-added shares (per cent change)



Note: Panel 1 summarises the observed structural changes, as shares of GDP. Panels 2 to 6 summarise the simulated changes resulting from the shocks specified.

Source: Authors' calculations from simulation results.