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Heterogeneity in Japanese TFP, Part 1: Why Overcoming Deflation Alone is Not Enough

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Heterogeneity in Japanese TFP, Part I

Why Overcoming Deflation Alone Is Not Enough

Abstract

The first in a two-part series on Japanese total factor productivity, this paper presents an analytical argument for a non-monetary structural reform policy pillar based on the assumption that overcoming deflation, while arguably a necessary precursor to reform, is not in its own right a solution to Japan's structural ailments. Our analytical evidence takes the form of comparative calibrated simulations of aggregate Japanese growth accounting using the neoclassical growth model, first with and secondly without accounting for Investment Specific Technology (IST). We find that the IST-adjusted model better explains Japanese growth accounting during the "lost decades" than the base-case model. The implications of this outcome are as follows: IST represents a type of relative deflation – the decline in capital goods prices in terms of consumption units. Structurally, this contributes positively to total factor productivity. We supplement this with counterfactual analysis: were deflation the primary causal trigger for Japan's structural decline, sector decomposition of growth accounting should show leading price declines in the worst performing sectors in terms of TFP. This is not the case. When we decompose Japanese growth accounting by sector, we find that the sectors responsible for the slowest TFP growth and those furthest from the "balanced growth path" characterized by theory neither showed the first, deepest, nor most consistent negative growth in deflators. Rather, the most deflationary sectors were out-performers in terms of TFP and those that demonstrated characteristics of a "balanced growth path," tending to belong to manufacturing (rather than nonmanufacturing) and IT (rather than non-IT) industries.

Introduction

Amid a wealth of "lost decade" literature, hearty debate still surrounds the causes of Japan's descent into deflationary sub-potential growth. One consistency among existing studies is that, by most measures, aggregate total factor productivity growth stagnated during the period immediately following the bursting of Japan's stock market and real estate bubbles in 1990. Notwithstanding, there exists no consensus on the sources of this decline.

We begin our analysis by revisiting the neoclassical model of growth, and in our examination of economic aggregates obtain results in line with those obtained by Hayashi and Prescott (2002); our model produces macroeconomic aggregates roughly consistent with realized developments in labor, capital and total factor productivity.

We then introduce an innovation to the original Hayashi and Prescott model in the form of Investment Specific Technology (IST), whereby we calibrate distinct deflators for final consumer goods and capital goods. Subsequently, we perform parallel simulations using the new IST-consistent model alongside the original base-case model, and discover that the latter delivers a significantly better fit when simulating economic aggregates. Our simulation results tell us that IST is responsible for roughly one-third of aggregate TFP growth from 1970 to 2008. Though lacking in explanatory power of the drivers of the TFP slump itself, our results argue in favor of macroeconomic policies that acknowledge the contribution of cost-saving technologies to TFP growth; that policies acknowledging the role of IST may be more appropriate than those focused upon a singular consumption deflator.

We go on to perform an industry-level disaggregation of growth accounting. We examine whether comparative developments in industry sector aggregates, and indeed in industry-level growth accounting offer heterogeneous results when in regard to Japanese TFP growth. Upon disaggregating by industrial sector, we find a large divide between manufacturing and services-sector TFP growth, which has remained significant since the 1990's. Even greater still however, is the divide between IT and Non-IT industries; the gap in TFP growth between the two gradually widened from the 1990's to date. As IT industries improved, TFP growth of Non-IT industries actually deteriorated from the mid-1980's to date. Finally, we compare our sector analysis with industry level analysis, to examine whether the "best" and "worst" performers in terms of TFP conform to our aggregate sector results. On industry level, we find that our sector divides persist as signaled by sector aggregates.

I. What the Neoclassical model tells us about Japan's "lost decade"

Our point of departure is the influential Hayashi-Prescott (2002) paper whose central assumption is that the slump in Total Factor Productivity during the 1990's did indeed follow the textbook response of reducing the balanced growth path, and increasing the steady-state capital-output ratio. While we note in passing the second premise of the Hayashi-Prescott paper, the influence of the reduction of the workweek length, as a factor in shifting the absolute level of the balanced growth path downward, we focus specifically on the drivers of Japanese Total Factor Productivity growth.

To provide basis for comparison, we revisit ground broken by Hayashi and Prescott. We start with a world without heterogeneity in TFP by calibrating a simple Neoclassical Model of Growth using data from the OECD, Japan's Cabinet Office and the Ministry for Internal Affairs and Communications. We calibrate parameters δ (depreciation) and α (marginal product of capital), assuming a one-sector closed economy (C + I = Y) with a CRS Cobb-Douglas production function $Y=AK^{\alpha}L^{1-\alpha}$ wherein capital observes the law of motion of capital: $K_{t+1}=K_t(1-\delta)+I_t$. The details of our initial calibration are included in Appendix 1. Our initial calibration, based on data between 1970 and 2010, revealed alpha (α) to be around 0.4172, and delta (δ) at slightly above 7%.

Figure 1: Japanese Growth Accounting, 1970-2008

Figure 1 shows key growth accounting aggregates recovered from our base case calibraton exercise. Per-capita output (Y_t/N_t) has largely followed the same path as Total Factor Productivity ($A_t^{1/(1-\alpha)}$, or the Solow residual). We examine the model over time, with reference to Kaldor's stylized facts (Kaldor 1957). We observe that even though growth of Japanese total factor productivity was consistent with the fast pace of output growth in the 1970's, the series followed a volatile path when subsequent years are taken into account, stagnating during the "lost decade" (as Hayashi and Prescott have noted, contributing 0.43% of the 3.95% decline in growth between the periods of 1983-1991 and 1992-1998) and then picking up again in recent years (until the time of the Lehman shock in 2008, the start of the Global Financial Crisis).

Though the capital-to-output ratio (K_t/Y_t) has remained roughly steady in this model, we acknowledge the gradual decline in labor hours per worker (L_t/N_t) since the 1970's. As one partial explanation of this factor, Hayashi and Prescott had put forward arguments concerning the shortening of standard workdays, which they admit, however cannot explain the slump in the rate of TFP growth.

Business cycle facts reveal why we should care about TFP (structurally)

The fundamental nature of our analysis in this paper is structural, rather than cyclical. That said, business cycle analysis does reinforce our choice to focus on the slump in TFP as a structural phenomenon. We observe, when examining the HP-filtered cyclical component of TFP starting in the 1990's, that the slump in TFP is not stationary but declining on trend. This is not to say that the drop in TFP is unique in its structural nature. Hayashi and Prescott emphasized in their 2002 paper that while the fall in the growth rate of total factor productivity had the most important effect in the 1990's of reducing the steady-state growth path and increasing the steady state capital-output ratio, a shortening of the workweek in stages from 1988 through 1993 (due to revisions in the Labour Standards Law of 1988), also coincided with the drop in TFP growth. Since then however the coincidence has disappeared; since 1993, we witnessed recovery in TFP in the absence of any recovery in man-hours worked. Here, we might anecdotally interject the hypothesis that demographic factors, such as the decline of Japan's population might have actually been offset by phenomena such as the offshoring of labor. Outward investment in the manufacturing industry in particular, might have contributed to the rebound in productivity; indeed we see evidence of a healthy rebound in the early 2000's in manufacturing productivity especially, in the absence of a rebound in hours worked.

For the purposes of our study, in summary, we examine TFP growth as independent to the trend decline in labor hours.

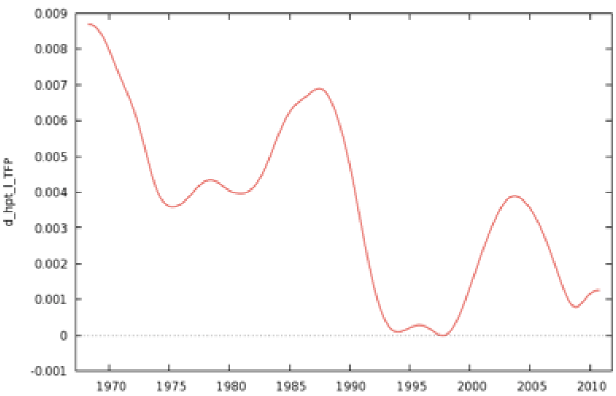

Figure 3: A slump in cycle-adjusted TFP growth

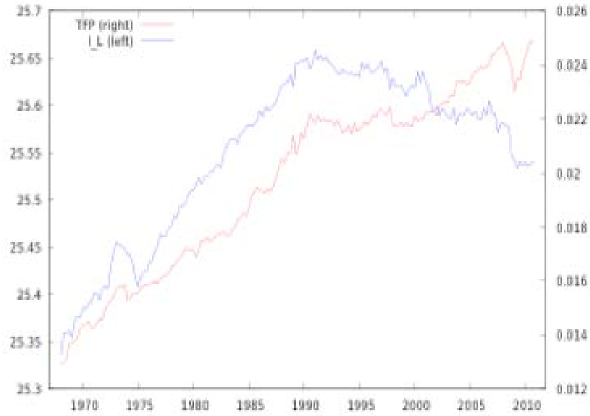

Figure 2: Breakdown in the relationship between TFP and man-hours worked

Further details on our business cycle analysis may be found in Appendix 1.

Growth accounting decomposition per NMG by industrial sector

Having established the relevance of our structural examination of TFP in the contexts of Growth Accounting and Real Business Cycle analysis, we now engage in our first examination (still in the Neoclassical Growth Model framework) of industrial sector heterogeneity of Japanese TFP.

Data: To obtain our sector-specific growth accounting, we obtain the following data series on 108 industries and three industry aggregates (Manufacturing, Non-manufacturing and Macroeconomy) from the JIP database:

- CoE: Compensation of Employees
- NV: Nominal value added (as a means of comparison to nominal GDP)[1]
- CFC: Consumption of Fixed Capital
- DEF: Sector Deflators, calculated from Real and Nominal gross output
- Y (RNV): Real value added (to compare to real GDP)
- TaxSub: Taxes less subsidies
- MH: Man-hours worked
- WL: Nominal Labour Costs
- K (K_T): Real net capital stock
- N: Workers per industry

We supplement the existing data by performing our own calculation of aggregates (once again following JIP methodology and paper by Miyagawa and Hisa (2013) for IT, Non-IT and Services sectors[2].

Methodology of sector calibration: Using data series obtained, we calculate labour's share by dividing nominal Compensation of Employees by nominal value-added, or 1-α. From this, we obtain α (capital's share). Our calibration of industry alpha is the average of annual observations from 1970 to 2009. We calibrate delta (δ) similarly by taking the average over the same period of consumption of fixed capital (CFC) over capital stock (K), using available JIP data on stock of capital by industry and real value-added per industry to calculate $K/Y^{\frac{\alpha}{1-\alpha}}$, similarly obtaining output per worker by dividing real value added output Y (RNV) by MH.

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[1]Nominal Value added in the JIP data base is calculated as follows:

$$\frac{\dot{V}}{V} = \frac{1}{\sum_{j=1}^{N} q_j V_j} \sum_{i=1}^{N} \left\{ p_{Q_i} Q_i \frac{\dot{Q}_i}{Q_i} - \sum_{j=1}^{N} p_{X_j} X_{ji} \frac{\dot{X}_{ji}}{X_{ji}} \right\}$$

$$= \sum_{i=1}^{N} \frac{p_{Q_i} Q_i}{\sum_{j=1}^{N} q_j V_j} \left\{ \frac{\dot{Q}_i}{Q_i} - \sum_{j=1}^{N} \frac{p_{X_j} X_{ji}}{p_{X_i} Q_i} \frac{\dot{X}_{ji}}{X_{ji}} \right\}$$

$$= \sum_{i=1}^{N} \left\{ \frac{p_{Q_i} Q_i}{\sum_{j=1}^{N} q_j V_j} \frac{\dot{Q}_i}{Q_i} \right\} - \sum_{i=1}^{N} \left\{ \frac{\sum_{j=1}^{N} p_{X_j} X_{ji}}{\sum_{j=1}^{N} q_j V_j} \sum_{j=1}^{N} \frac{p_{X_j} X_{ji}}{\sum_{j=1}^{N} p_{X_j} X_{ji}} \frac{\dot{X}_{ji}}{X_{ji}} \right\}$$

$$= \sum_{i=1}^{N} \left\{ \frac{p_{Q_i} Q_i}{\sum_{j=1}^{N} q_j V_j} \frac{\dot{Q}_i}{Q_i} \right\} - \sum_{i=1}^{N} \left\{ \frac{\sum_{j=1}^{N} p_{X_j} X_{ji}}{\sum_{j=1}^{N} q_j V_j} \frac{\dot{X}_{ji}}{X_{ji}} \right\}$$

Reference, from JIP: *Seisansei to Nihon no Keizai Seicho: JIP Database ni yoru Sangyo/Kigyo Level no Jissho Bunseki* [Productivity and Japanese Economic Growth: Empirical Analyses Using Industrial and Firm-Level Data from the JIP Database], edited by K. Fukao and T. Miyagawa, University of Tokyo Press, March 2008.

[2] While Manufacturing and Non-manufacturing add up to 100% share of the macroeconomy, as do the separate categorizations of IT and Non-IT, the Services sector remains a subset of non-manufacturing.

We also obtain a measure of labor hours per worker (L/N) by dividing man-hours (MH) by number of workers per industry (N), in the obvious absence of industry-specific population. We finally recover TFP by sector, dividing (Y) by $K^{\alpha}L^{1-\alpha}$.

Regarding industry-level calibrations, we note that availability of accurate data on capital and labour shares remains one constraint to computation of the Solow residual by industry; data for man-hours in the Housing sector for instance was preventively sparse, resulting in an unreliable reading for Housing sector alpha of greater than 1. In such instances where average alphas were not between zero and one, we omit the series from the calibration. Our calibrations for aggregates of interest are as follows:

	α	$1 - \alpha$	δ
Manufacturing sector	0.355	0.645	0.0857
Non-manufacturing	0.301	0.699	0.0802
Macro economy	0.377	0.623	0.0644
IT sector	0.324	0.676	0.0950
Non-IT sector	0.330	0.670	0.0520
Services	0.330	0.670	0.0535

Figure 4: Calibrations of Alpha, 1-Alpha and Delta by Industry Aggregates

Individual industry calibrations are available in Appendix 2.

In general, we notice (as one would expect) higher Alpha in manufacturing relative to nonmanufacturing, where labour shares were higher. We note that alpha for the economy as a whole at the beginning of our sample period tended to run alongside that of the manufacturing sector, but are now superior to those of our main aggregate sectors. As expected, sectors highly dependent on capital inputs such as Petroleum products and Electricity and Office Equipment Leasing demonstrated the highest alphas.

Many of the most capital-intensive industries belonged to the non-manufacturing, non-IT sectors, even though, on average, manufacturing is more capital intensive (higher alpha) than non-manufacturing, IT higher than non-IT.

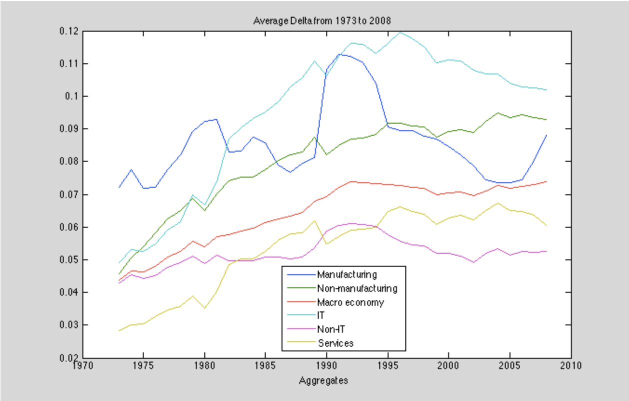

Figure 5: evolution of delta by Aggregate

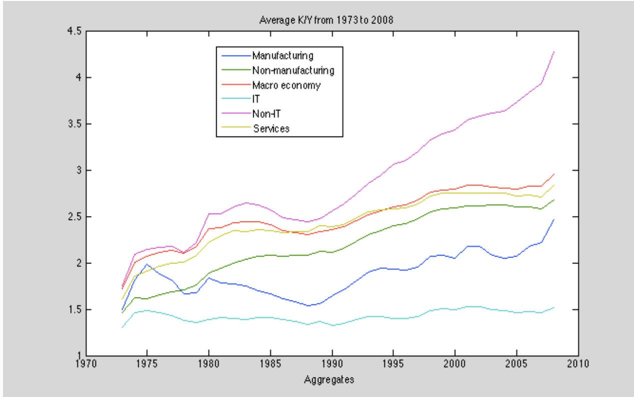

Figure 6: Evolution of K/Y

In regard to the rate of depreciation, we note that the IT sector had the highest delta, which however peaked in the mid-1990's. We also observe a spike in manufacturing delta right at the start of the 'lost decade', when manufacturing output suffered a shock and hence capital-to-output ratios (K/Y) in the manufacturing sector troughed, subsequently embarking on a rebound that lasted until the mid-1990's.

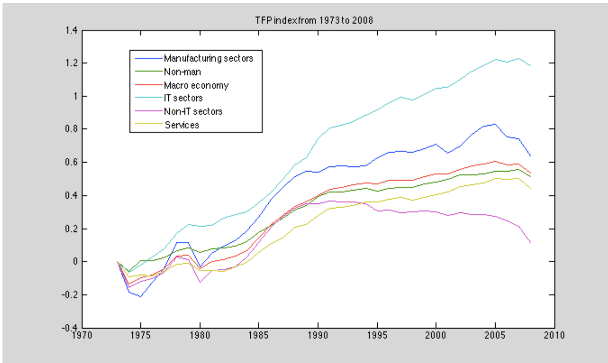

Figure 7: TFP (indexed at 1973=1)

Lastly, we observe the growth in Solow residuals (from base year 1973), where an important comparison comes to light. Much as we witnessed the substantially greater divide between IT and non-IT sector capital/output ratios than in manufacturing versus non-manufacturing, a similarly massive divide splits IT and non-IT total factor productivity growth over the years, much more so than manufacturing versus nonmanufacturing TFP growth. The IT sector, while growing at a slower pace than in the 1980's out-performed the rest of the economy from the 80's onward. Meanwhile, TFP growth in the non-IT sector actually deteriorated over the same latter period. Meanwhile, even though capital-to-output (K/Y) adjusted for labour's share followed similar paths in both manufacturing and nonmanufacturing sectors (despite clear under-performance of the latter in terms of TFP), capital-to-output in IT sector and non-IT sectors followed notably distinct paths. While in the IT sector, K/Y changed hardly at all over the observation period, in the Non-IT sector K/Y built massively in the 1980's to remain at an elevated level through the 1990's and to date.

Evaluation: The obvious absence of perfectly analogous data series on a sector or industry level to those used to compile aggregate growth accounting (the absence of sector-specific household mixed income or depreciation, for example) explains discrepancies between our initial aggregate model and re-aggregated growth accounting for the macro-economy as a whole.

Yet amongst our industry-level sector aggregates it is possible to compare like-for-like given consistent methodologies. When we do so, we observe the distinct split between manufacturing (a profile much more akin to a balanced growth path per Kaldor stylized facts) and nonmanufacturing, and an even greater contrast

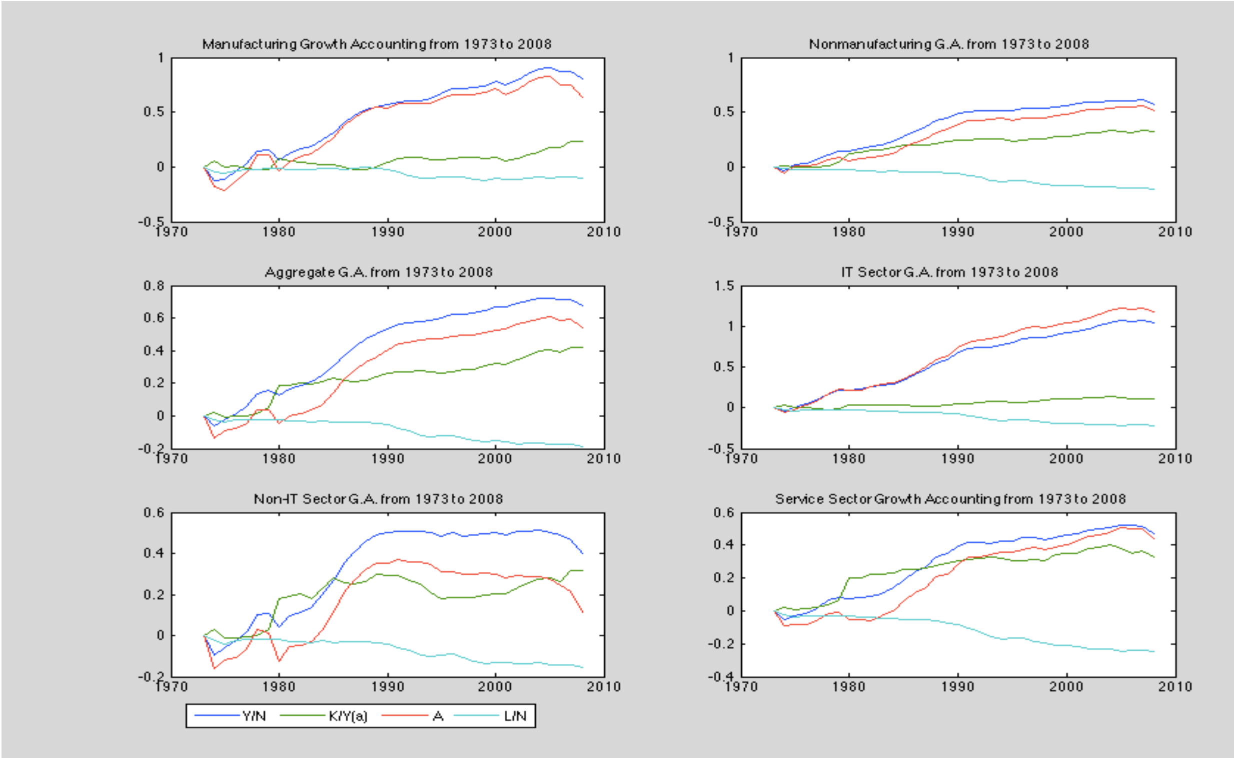

Figure 8: Growth Accounting by Industry Aggregates

between IT and Non-IT sectors. We find nonmanufacturing sector growth accounting (given its dominance in terms of share of GDP) similar to that of our industry-aggregated overall output. We note here that neither is indicative of a balanced growth path (see Figure 8).

While in both the manufacturing and nonmanufacturing sectors, the Solow residual cleaves tightly to labour's per-capita output, the capital to output ratio drifts upward for nonmanufacturing. Given nonmanufacturing accounts for around 60% of the total economy by production, its similarity to the aggregate capital to output ratio is trivial.

We see an even more polarized picture when we examine the IT versus non-IT sectors. In the IT sector, TFP follows output per capita upward (a characteristic of a balanced growth path, per Kaldor stylised facts), but in the non-IT sector, we witness deterioration in TFP near the end of our sample, while at the same time we observe a rise in capital to output ratio.

Interestingly, the stark contrast between the rates of Total Factor Productivity (measured by the Solow residual) in sectors related to production of IT goods and services, and their non-IT goods and service-producing counterparts not only characterizes aggregates, it **persists at the extremes at individual industry level.** We see that manufacturing, IT-producing sectors remain at the technology frontier; between 1973 and 2008, only one non-manufacturing (Services) sector fell within the top 10 (of 97) private-sector industries in terms of productivity growth; and this was Telegraph and Telephone, which is classified as an IT-related sector:

Top 10 by TFP growth 1973-2008	%	Manuf.	IT	Non-IT	Services
Electronic data processing machines, digital an analog computer equipment and accessories	4.98	x	x		
Telegraph and telephone	4.52		x		x
Semiconductor devices and integrated circuits	3.80	x	x		
Communication equipment	3.23	x	x		
Household electric appliances	3.06	x	x		
Electronic parts	2.78	x	x		
Pharmaceutical products	2.74	x	x		
Office and service industry machines	2.74	x	x		
Electronic equipment and electric measuring instruments	2.02	x	x		
Motor vehicles	1.72	x		x	

Figure 9: Top ten industries in terms of TFP growth 1973-2008, as member of aggregate

When we examine the worst-performing industries in terms of TFP growth between 1973 and 2008, we observe that the manufacturing/non-manufacturing split is not as clear as among the best-performing:

Bottom 10 by TFP growth 1973-2008	%	Manuf.	IT	Non-IT	Services
Petroleum products	(9.66)	x		x	
Basic organic chemicals	(8.08)	x		x	
Prepared animal foods and organic fertilizers	(6.83)	x		x	
Coal products	(6.79)	x		x	
Real estate	(3.53)			x	x
Organic chemicals	(3.40)	x		x	
Electricity	(3.33)			x	x
Chemical fertilizers	(3.25)	x	x		
Waste disposal	(2.98)			x	x
Rice, wheat production	(2.78)			x	

Figure 10: Bottom ten industries in terms of TFP growth 1973-2008 as member of aggregate

Once again however, the divide between IT-related and non-IT sectors is striking. Only one IT-related sector appears among the worst-performers (in terms of TFP growth) over the 1973-2008 period - Chemical fertilizers, a sector wherein manufacturers are involved in all manner of chemical products, both high-and low-tech.

Lastly, we notice that dissimilarity persists between IT and non-IT sectors when we examine the relative output deflators for each industry. Out-performance of the Japanese IT sector in terms of TFP growth was accompanied by price deflation in the sector, a phenomenon that alongside our simulation in section 2 (see Figure 11) argues that heterogeneity in total factor productivity and relative price developments are not unrelated.

Deflators stagnated for most of the lost decade among most of our aggregates, but started picking up again in the mid-2000s (particularly for the non-IT sector). The IT sector was an exception; the deflator remained entrenched in a downtrend, with the downtrend gaining additional momentum in the last years of our sample.

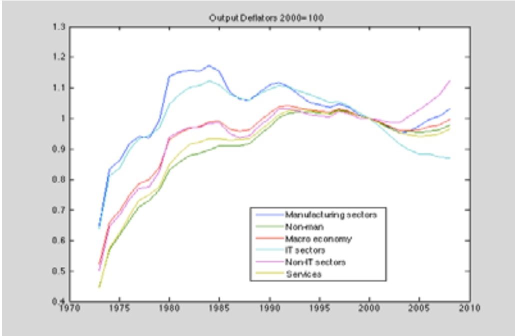

Figure 11: Deflation in the IT sector

Informed by evidence of distinct disparities between IT and non-IT sectors in particular, we return in our next section to aggregate analysis. In light of the stark productivity divide between sectors, particularly between IT and non-IT sectors with higher capital shares of output – moreover in the presence of price deflation in the leading edge IT sector, we attempt to address the question of whether a one-sector model adequately captures the heterogeneity that our industry-level disaggregation of TFP has unveiled.

II. Our simulations tell us not to ignore investment specific technology

Using information gleaned from our growth accounting exercise, we now turn to simulation to evaluate the efficacy of our model's calibration as well as in understanding the role of investment-specific technology as a driver of growth in output and productivity. Our main evaluation framework remains the Neoclassical Model of Growth, and we maintain as our base-case our Hayashi and Prescott-inspired model when in regard to simulation, thereupon adding to it an Investment-Specific Technology component.

In order to uncover the benefits of including investment-specific technology as a factor, we first recalibrate our simple one-sector NMG (based on economic aggregates consistent with OECD methodology). We recalibrate our model roughly to fit the timeframe of our industry-level JIP data and perform our base case simulation following the model employed by Great Depressions collaborators Conesa, Kehoe, and Ruhl (2008).

Recalibration: As before, we solve simultaneously for K_0, delta and alpha. As expected, we obtain very similar values for parameters delta and alpha, recalibrated from 1975 and 1980 through 2010 respectively, and recover K_0 as follows:

β	ϒ	δ	α	g	η
0.9708	0.3291	0.04848	0.41085	1.0162	0.99434 1

We consider three potential periods for Beta and Gamma, deciding in favour of the period between 1980 and 1999 in order to encompass a full cycle, and a volatile one at that, starting with the boom period of the 1980's as well as the Lost Decade thereafter. Beta and Gamma are calibrated as follows:

$$\beta = C_{t+1}/C_t(1-\delta+\frac{\alpha Y_t}{K_{t+1}})$$
$$\gamma = C_t Y_t/Y_t(hN_t - L_t)(1-\alpha) + C_t L_t$$

Parameter g represents the average rate of growth in TFP over the entire observation period, while η represents a steady exponential growth rate of order 2 starting at the end of our sample.

Simulation: We follow the CKR methodology and model for our simulation:

$$max \sum_{t=T_0}^{\infty} \beta^t \left(\gamma \log C_t + (1-\gamma)\log(hN_t - L_t)\right)$$

subject to:

$$C_t + K_{t+1} \leq w_t L_t + (1+\delta+r_t)K_t$$

$$C_t, K_t, L_t \geq 0, \quad L_t \leq hN_t$$

$$K_{T_0} \text{given}$$

Meanwhile, equilibrium conditions dictate that (alongside the first order conditions of the firm):

$$r_t = \alpha A_t K_t^{\alpha-1} L_t^{1-\alpha}$$

$$w_t = (1-\alpha) A_t K_t^{\alpha} L_t^{-\alpha}$$

and feasibility condition:

$$C_t + K_{t+1} = A_t K_t^{\alpha} L_t^{1-\alpha} + (1-\delta)K_t$$

Using Newton's method, we solve the system of equations and recover simulated series for output and investment per capita, the consumption/output ratio, and capital/output. We also recover interest rates net of depreciation.

Base case results: Our base case simulation, while not entirely dissimilar to the observed data, still shows room for improvement in estimation:

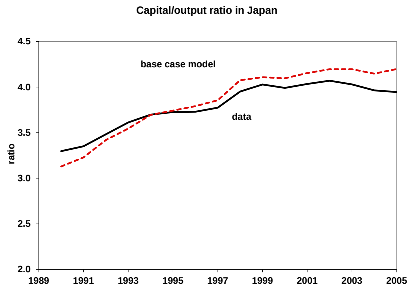

Figure 12: Capital Output ratio in Japan (1989-2005)

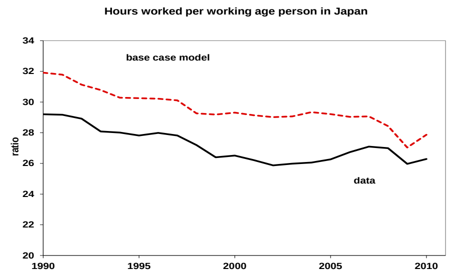

Figure 13: Hours worked per working age person in Japan (1990-2010)

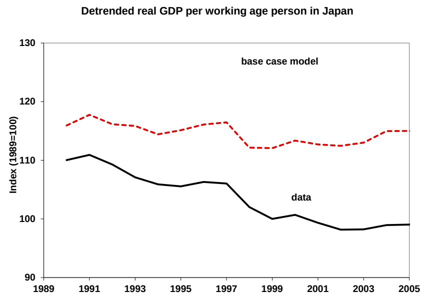

Figure 14: Detrended real GDP per working age person in Japan (1989-1005)

We might remark, for instance, that while our base case model offers a relatively accurate simulation of the build-up in the ratio of capital to output (the slope of the series is mildly steeper than the series in the data), it systematically over-estimates the ratio of hours worked per working-age person. As for output per capita (labour productivity, for the layperson), the model not only systematically overestimates the ratio, but under-estimates its decline, over some periods missing the decline entirely during the 'Lost Decade' of the 1990's.

Model 2, using investment-specific technology: In search of a better estimate of economic conditions surrounding Japan's 'Lost Decade', we focus upon the distinct moves in relative deflators. We alter our Base Case model to accommodate investment-specific technology, using as a guide the work of Braun and Shioji (2007).

The calibration follows similar methodology to our base case, except for a slight change in our calibration variables (and hence our parameters), as well as our model. The household's new budget constraint is:

$$C_t + \frac{K_{t+1}}{V_t} = \frac{(1-\delta)K_t}{V_t} + R_t K_t + w_t h_T N_t$$

and while the law of motion of capital remains $K_{t+1}=K_t(1\text{-}\delta)+I_t$, the variable I no longer represents a uniformly-deflated component of output. The feasibility condition representing output is now $C_t + X_t = Y_t$, where Y and C are deflated by the consumption deflator, and X represents the consumption of investment firms, also deflated by the consumption deflator. The relationship between X_t and I_t is now determined by the investment specific technology term, V_t, which in equilibrium also represents the inverse of the price of capital in terms of consumption units. As such, the new δ that we calibrate describes the relationship between XV and capital which in turn shifts the estimate of K_0 and the $\hat{r}$ that we recover from the Euler equation:

$$\frac{C_{t+1}}{C_t} = \beta(1-\delta+\hat{r}_{t+1})$$

will be rV, the marginal product of capital in units of investment rather than consumption. Our new parameters β and ϒ also change to reflect the new variables:

β	ϒ	δ	α	g	η
0.9441	0.3291	0.0607	0.41085	1.0116	0.9943

In practical terms, we deflate overall GDP by the consumption deflator (aggregate series obtained from the OECD database), while deflating nominal investment first by the same deflator to obtain X (consumption by firms), then recovering I by multiplying by the inverse of the ratio of the investment to consumption deflators, otherwise known as our factor of technology V. Below, we witness the heavily deflationary pull at play in the investment goods sector with relation to the consumption sector, from 1970 onward.

We remark the steep slope of descent in the price of investment goods relative to the price of consumption goods which even before running our simulation, portends a distinct result from our one-sector simulation:

Figure 15: Relative price of capital/consumption goods, '1/V'

Indeed, performing the simulation, we do obtain distinct results from the base case; we note that, overall, the simulation produces results much closer to the data than its one-sector counterpart.

We take especial note of the much tighter fit between the model and simulated Y/N, for example, than in our Base Case model, both in terms of levels and in terms of gradients:

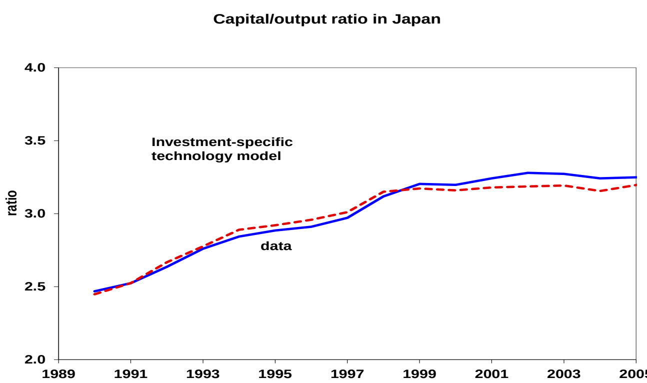

Figure 16: K/Y for IST model vs data

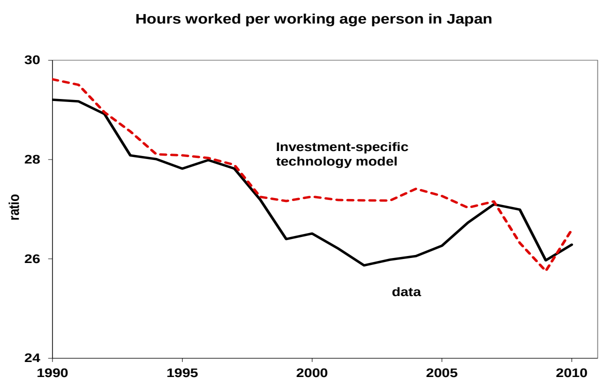

Figure 17: L/N for IST model vs data

We do note that there remains a significant dip in L/N during the mid-2000's that is *not* well-estimated by adding investment-specific technology to the model, leading us to suspect that the deflationary pressures of investment goods alone do not sufficiently explain the drop in working hours over this period. However, following this period, we also note that the model resumes its tighter fit.

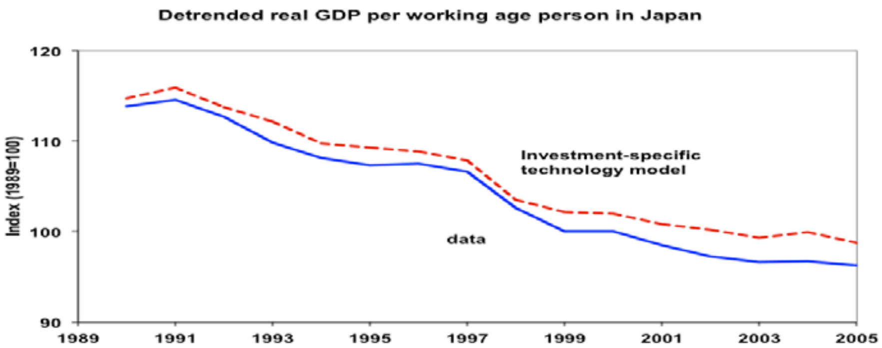

Figure 18: Y/N for IST model vs data

With this simulation, we start to answer questions about the contribution of investment-specific technology to overall TFP. While we cannot compare levels directly (due to the differences in model variables), we might compare simulations of TFP growth between 1970 and 2010; the gap between the two models tells us that **roughly one-third of TFP growth over this period was attributable to investment-specific technology**. This point is germane to our line of analysis; the contribution of investment specific technology to TFP is sizeable enough that heterogeneity of technology merits further investigation.

Evaluation: In the first section of our analysis, we discovered consistently divergent profiles in total factor productivity between manufacturing and nonmanufacturing, as well as between IT and non-IT sectors. The particularly stark divide between the latter sectors' productivity and capital-to-output ratios (despite relatively similar capital shares of output) led us, via simulation, to examine the role of Investment-Specific Technology (proxied by relative price moves) in contributing to the overall growth of TFP. We found that the neoclassical model of growth altered for IST provided a better simulation of TFP growth between 1970 and 2010 than our base-case model.

Policy implications: Though ideas presented in this paper may appear abstract to policy practitioners, their practical interpretation holds meaningful implications for policy. Firstly, our analysis has revealed something important about the nature of total factor productivity; we have achieved an estimate of how great a contributor the decrease in cost of capital achieved by technology is to overall productivity over time.

Our results also tell us that although inflation may very well be always and everywhere a monetary phenomenon, *relative* price moves are not necessarily endogenous to supply of money, but are non-negligible contributors to total factor productivity, a structural driver of GDP growth. From a policy perspective, we might argue that if indeed as we put forward, the long-term stagnancy of Japanese TFP is indicative of a structural malaise, simply achieving reflation – a cyclical monetary phenomenon, does not represent any definitive cure.

Acknowledging the corrosive nature of persistent deflation on firm balance sheets and household wealth, it is perhaps more accurate to describe conquering deflation as a *necessary but insufficient condition* for Japan to regain its balanced growth path. Otherwise stated, investment specific technology represents a type of "healthy" relative deflation (representing a decline in capital costs) that might, all else equal, give rise to expectations of real wage increases, which represent one central aspect of "healthy" reflation. The "health" of this combination is a target of structural rather than monetary policy reform, given the latter is a blunt tool targeting overall inflation expectations via the supply of money rather than relative price changes. In other words, we have established a clear theoretical foundation whereby to argue that monetary reflation on its own is not enough to pull Japan out of the negative cycle of its "lost decades" of growth, that these depend heavily on the implementability, quality and credibility of "third arrow" structural reforms.

Direction for further analysis: Our results argue in favor of recognizing industrial heterogeneity in total factor productivity when in regard to policies targeting structural reform. Our decomposition of Japanese growth accounting at industry level clearly reveals specific industries and sectors where structural problems lie.

To some degree, we are equipped with tools to critically assess the ongoing implementation of structural reform under Abenomics. For example, while it is encouraging to see that the Abe administration appears to have recognised the importance of bolstering productivity to combat stagnancy in growth longer-term, there are few signals that the administration is targeting the lowest-performing industries for reform.[3]

Similarly, the government's recent recognition of the services sector as targets for reform is heartening; yet within this cadre, its focus on IT-related industries in its updated growth strategy released in June 2015[4] is not. In light of what we know about the out-performing nature of TFP in the IT sector (both on the services and manufacturing side) appears suspiciously more about "picking winners" rather

[3] Nikkei Asia Net (22 Jun 2015) http://asia.nikkei.com/Politics-Economy/Economy/Japan-aims-for-productivity-reform-as-key-to-growth

[4] Japan Cabinet Office (22 June 2015) http://www5.cao.go.jp/keizai-shimon/kaigi/minutes/2015/0622/shiryo_01.pdf

than implementing tough changes in those sectors most in need of productivity improvements.[5]

We still however have little basis whereupon to comment on the shape structural policy reforms must assume, and what influence they might or might not have on industrial-level and on aggregate TFP remains to be seen. In order to examine *how* effective incentives might be designed to remedy poor productivity in afflicted sectors (e.g. non-manufacturing, services and non-IT sectors) we engage, in our subsequent paper, in a treatment of TFP as an endogenous variable. In the second paper in this series, we will shift our focus away from the neoclassical model of growth (where TFP is typically exogenous), toward empirical analysis examining potential drivers of TFP growth, with specific examination firstly of regulatory changes and secondly of capital allocation, and their relationship with TFP.

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[5] http://www.reuters.com/article/2015/06/11/japan-economy-growth-idUSL3N0YX2CU20150611

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Appendix 1: Notes on compilation of Growth Accounting and Business Cycle Facts

Growth Accounting - Methodology and data

Methodology: With the objective of examining the relative contributions of labour, capital and total factor productivity to output, we calibrate a simple Neoclassical Model of Growth using data from the OECD, Japan's Cabinet Office and the Ministry for Internal Affairs and Communications for parameters δ (depreciation) and α (marginal product of capital), assuming a one-sector closed economy ($C + I = Y$) with a CRS Cobb-Douglas production function $Y=AK^{\alpha}L^{1-\alpha}$ wherein capital observes the law of motion of capital: $K_{t+1}=K_t(1-\delta)+I_t$ whereupon we use the parameters we obtain to calculate values for Capital (K) and Total Factor Productivity (A).

Data, OECD: We obtain data in annual observations on Japan's National Accounts from the OECD. Series obtained include:

- Real and Nominal GDP,
- Population aged 15-64
- Gross Capital Formation
- Gross Operating Surplus and mixed income (for Households, Whole economy),
- Consumption of Fixed Capital (Households, Whole economy)
- Annual Total Hours Worked and Taxes – subsidies.

Data were mostly available from 1970, beside Consumption of Fixed Capital, for which data from 1980 to 2001 were taken from the ESRI website, and reflated appropriately (1995=100). We performed various sets of calibrations for the parameter α (Capital's share of income) from 1980 onward, which we discuss below. The investment series used in this file is the series of nominal investment 1970-2010, deflated by the GDP deflator in 2005=100 terms (the OECD's deflator base year).

Calibration of one-sector NMG, 2001-2010

- **Calibration of α (Capital's share)**: In order to derive α, we first find $1-\alpha$ (labour's share) using Compensation of Employees, from OECD National Accounts data),divided by GDP-Household Net Mixed Income – Indirect taxes. In order to derive household mixed income, we have used the Consumption of Fixed Capital data from Japan's National Accounts (1980-2001), followed by OECD data for 2001-2011. As Hayashi and Prescott (2002) noted however, depreciation in Japan's NIA (National Income Accounts) represents book-value depreciation rather than market-value, which as might make a sizeable difference in calibrating alpha (given household depreciation is subtracted from Mixed Income, which we subtract from GDP, which contains overall depreciation). The results might have been particularly distortionary in periods where the gap between book and market value would have been especially wide. For this reason, I have used the period 2001-2010 for my calibration, which at least would produce more consistent results with respect to other developed countries, per the OECD methodology.

- **Calibration of δ, Capital stock:** Using a similar method to that used by Conesa, Kehoe and Ruhl in *Great Depressions* (see references), we used the perpetual inventory method and law of motion of capital to solve for both delta and initial capital (K_0) simultaneously. We start with initial guesses for delta and for initial capital, at 5% and 3-times 1970 GDP respectively. Then, setting the δ/K^*Y calculated using using my constructed capital series equal to depreciation/GDP in the national accounts, we selected the optimal levels of initial capital (K_0) and δ also setting a constraint upon Capital/Output ratio (K/Y) in 1970, setting this equal to the average K/Y over the following decade. we performed this over four different periods – the period 2001-2010, for which a full (consistent) set of data was available, for the "boom years" of 1984-1989 and the decade 1980-1990. The deltas obtained using data for "boom years" were lower than that of the entire sample, and over the sample period that we chose for calibration, 2001-2010.

Business cycle facts: Methodology and data

Methodology: We use quarterly components of production (as seen in the NMG, applied for growth accounting) to calculate new quarterly series for capital (K) and thus TFP (A), using parameters α and δ as determined in the annual growth accounting exercise ($e^{\delta t}$ for delta to reflect quarterly depreciation, while keeping alpha unchanged because of CRS).

We then log-linearise six variables and apply an HP filter to isolate their trend and cyclical components. We examine the correlations between the cyclical components, also examining their standard deviations, as well as relative standard deviations versus GDP. Lastly, we examine 4 lags of all variables, and their relationship (leads, lags) with respect to Output (Y).

Data: From the OECD, we take quarterly observations of GDP, the GDP deflator (2005-=100) Final Consumption Expenditure, Gross Fixed Capital Formation (GFC data was only available since 1994), Public Consumption as well as Net Exports, though it must be noted that Net Exports are only available on a quarterly basis since 1994.

From Japan's Ministry of Internal Affairs and Communcations, we take aggregate weekly working hours (in mns), available in monthly observations. After annualising these observations, we also take a 3-month average for each quarterly observation. The data are much smoother (given they are aggregates of average weekly hours worked) than the annual OECD data on aggregate yearly hours, it must be noted. Still, the calculation of capital is roughly in line with what was obtained in the annual series, as is TFP.

We chose the period 1968-2010 due to availability of data (also because of several missing observations from the series of hours worked in 2011, thanks to the impact of the Great East Japan (Tohoku) Earthquake.

Parameters and variables:

- α Capital's share of income
- δ Quarterly rate of depreciation, , 0.017 (quarterly)

Exogenous:

- Y: Production (GDP, deflated at 2005=100)
- I: Investment, deflated at 2005=100
- L: Aggregate labour hours (annualised)
- GC: Government consumption
- C: Private-sector consumption
- Net Exports: only available on quarterly basis since 1994

Initial condition:
K_0: Initial level of capital
Calculated:
$K_{t:}$ Series of Capital flows, dependent on initial capital, investment and δ
A_t Total factor productivity, based on GDP vs production function.
Correlation matrix of cyclical components of logs of selected variables:

Variables	hp_l_Y	hp_l_TFP	hp_l_PC	hp_l_L	hp_l_I	hp_l_GC	hp_Net_Exports_GDP
hp_l_Y	1	0.9159	0.7529	0.6233	0.8304	-0.0633	0.0105
hp_l_TFP	0.9159	1	0.7132	0.3693	0.7026	0.058	0.0906
hp_l_PC	0.7529	0.7132	1	0.5583	0.5543	-0.1872	0.0279
hp_l_L	0.6233	0.3693	0.5583	1	0.5957	-0.261	-0.0455
hp_l_I	0.8304	0.7026	0.5543	0.5957	1	-0.1042	-0.231
hp_l_GC	-0.0633	0.058	-0.1872	-0.261	-0.1042	1	-0.0552
hp_Net_Exports_GDP*	0.0105	0.0906	0.0279	-0.0455	-0.231	-0.0552	1

* Net Exports/GDP data were only available on quarterly basis from 1994 onward

Standard deviations of selected variables (absolute and proportional to Y)

Variable	Std. Dev.	Standard Deviation/STDEV GDP
hp_l_Y	0.016072	1.000000
hp_l_TFP	0.013218	0.822391
hp_l_PC	0.016739	1.041475
hp_l_L	0.009503	0.591245
hp_l_I	0.043785	2.724248
hp_l_GC	0.017234	1.072248
hp_Net_Exports_GDP*	0.004207	0.261765

Leads and lags of selected variables with respect to output:

	Lags with Respect to Output (Y)				Comtemp.	Leads wrt Output			
	t-4	t-3	t-2	t-1	t	t+1	t+2	t+3	t+4
Y (auto)	0.0901	0.3589	0.5819	0.7968	1.0000	0.7968	0.5819	0.3589	0.0901
PC	- 0.0721	0.1826	0.3470	0.5418	0.7591	0.6346	0.4598	0.3591	0.1253
GC	- 0.2383	- 0.2899	- 0.2301	- 0.1790	- 0.0474	- 0.0820	- 0.0107	0.0373	- 0.0064
I	0.3465	0.5814	0.7480	0.8395	0.8367	0.5949	0.3734	0.1631	- 0.0230
L	0.0995	0.3162	0.4580	0.5656	0.6286	0.6015	0.4377	0.2620	0.1216
TFP	- 0.0711	0.1720	0.4072	0.6569	0.9211	0.7130	0.5337	0.3380	0.0620
Net Exports	- 0.3497	- 0.3692	- 0.3085	- 0.1674	0.0104	0.1113	0.1800	0.1328	0.1040

Note on dates: We have omitted years 1968-1969 as well as 2011-2012 from the leads and lags series, in order to compensate for observations omitted thanks to lags of up to four periods. We also omitted the period from 2011-2012 due to incomplete data around the time of the Tohoku disaster.

Appendix 2: Decomposition by industry of Japanese growth accounting

Methodology: We use the following sheets in the JIP database (2012) in order to compile industry-level annual-frequency data as well as aggregates (compiled using the JIP methodology):

1. Input output table (5) – distribution of gross value added (current prices)
2. Capital Input - Investment by sector
4. Growth accounting

We then used Matlab to prepare this data for panel data analysis

We calibrated the industry-level data for labour and capital's share using similar methodology as Conesa, Kehoe and Ruhl (2007), with the following exceptions:

- Indusry-levels for capital (K) were given in the data, as such we did not recalibrate capital – rather, we used K to calibrate alpha and delta.
- Given the obvious absence of household mixed income and depreciation at industry level, we made an assumption that the nominal value added per industry excluded mixed income, only including value-added production.
- Given the obvious absence of population growth by industry, we also omitted the growth accounting measure of L/N, at the industrial level. The analysis however has been included in our previous work on the entire economy.
- We used sector-level deflators based on gross output as the closest approximation to the industry's share of the GDP deflator
- Given certain fluctuations in the data, neither alpha and delta were guaranteed to stay below 0 and 1 for all observations, so we placed an artificial constraint on delta and alpha.

We then calculated TFP and Solow residual using our calculated labour and capital share, Net Value added minus depreciation, and man-hours.
We then proceeded to index TFP growth at base year = 1973 and compared the developments in our calculated TFP to that available within JIP (we explain the differences above).

Industry/Aggregation definitions

	Definition of aggregated sectors	201	202	203	204	205	206	207	208	500
JIP Classification no.	Industry name	Macro economy (excluding housing and activities	Market economy	Manufacturing sectors	Non-manufacturing sectors (excluding housing and	Non-manufacturing sectors (only market	Macro economy	IT sectors	Non-IT sectors	Services
1	Rice, wheat production	1	1	0	1	1	1	0	1	0
2	Miscellaneous crop farming	1	1	0	1	1	1	0	1	0
3	Livestock and sericulture farming	1	1	0	1	1	1	0	1	0
4	Agricultural services	1	1	0	1	1	1	0	1	1
5	Forestry	1	1	0	1	1	1	0	1	0
6	Fisheries	1	1	0	1	1	1	0	1	0
7	Mining	1	1	0	1	1	1	0	1	0
8	Livestock products	1	1	1	0	0	1	0	1	0
9	Seafood products	1	1	1	0	0	1	0	1	0
10	Flour and grain mill products	1	1	1	0	0	1	0	1	0
11	Miscellaneous foods and related products	1	1	1	0	0	1	0	1	0
12	Prepared animal foods and organic fertilizers	1	1	1	0	0	1	0	1	0
13	Beverages	1	1	1	0	0	1	0	1	0
14	Tobacco	1	1	1	0	0	1	0	1	0
15	Textile products	1	1	1	0	0	1	0	1	0
16	Lumber and wood products	1	1	1	0	0	1	0	1	0
17	Furniture and fixtures	1	1	1	0	0	1	0	1	0
18	Pulp, paper, and coated and glazed paper	1	1	1	0	0	1	0	1	0
19	Paper products	1	1	1	0	0	1	0	1	0
20	Printing, plate making for printing	1	1	1	0	0	1	1	0	0
21	Leather and leather products	1	1	1	0	0	1	0	1	0
22	Rubber products	1	1	1	0	0	1	0	1	0
23	Chemical fertilizers	1	1	1	0	0	1	1	0	0
24	Basic inorganic chemicals	1	1	1	0	0	1	1	0	0
25	Basic organic chemicals	1	1	1	0	0	1	0	1	0
26	Organic chemicals	1	1	1	0	0	1	0	1	0
27	Chemical fibers	1	1	1	0	0	1	0	1	0
28	Miscellaneous chemical products	1	1	1	0	0	1	0	1	0
29	Pharmaceutical products	1	1	1	0	0	1	1	0	0
30	Petroleum products	1	1	1	0	0	1	0	1	0
31	Coal products	1	1	1	0	0	1	0	1	0
32	Glass and its products	1	1	1	0	0	1	0	1	0
33	Cement and its products	1	1	1	0	0	1	0	1	0
34	Pottery	1	1	1	0	0	1	1	0	0
35	Miscellaneous ceramic, stone	1	1	1	0	0	1	0	1	0
36	Pig iron and crude steel	1	1	1	0	0	1	0	1	0
37	Miscellaneous iron and steel	1	1	1	0	0	1	0	1	0
38	Smelting and refining of non-ferrous metals	1	1	1	0	0	1	1	0	0
39	Non-ferrous metal products	1	1	1	0	0	1	0	1	0
40	Fabricated constructional and architectural	1	1	1	0	0	1	0	1	0
41	Miscellaneous fabricated metal products	1	1	1	0	0	1	0	1	0
42	General industry machinery	1	1	1	0	0	1	1	0	0
43	Special industry machinery	1	1	1	0	0	1	0	1	0
44	Miscellaneous machinery	1	1	1	0	0	1	0	1	0
45	Office and service industry machines	1	1	1	0	0	1	1	0	0
46	Electrical generating, transmission	1	1	1	0	0	1	1	0	0
47	Household electric appliances	1	1	1	0	0	1	1	0	0
48	Electronic data processing machines	1	1	1	0	0	1	1	0	0
49	Communication equipment	1	1	1	0	0	1	1	0	0
50	Electronic equipment	1	1	1	0	0	1	1	0	0
51	Semiconductor devices and integrated circuits	1	1	1	0	0	1	1	0	0
52	Electronic parts	1	1	1	0	0	1	1	0	0
53	Miscellaneous electrical machinery equipment	1	1	1	0	0	1	1	0	0
54	Motor vehicles	1	1	1	0	0	1	0	1	0
55	Motor vehicle parts and accessories	1	1	1	0	0	1	0	1	0

	Definition of aggregated sectors	201	202	203	204	205	206	207	208	500
JIP Classification no.	Industry name	Macro economy (excluding housing and activities	Market economy	Manufacturing sectors	Non-manufacturing sectors (excluding housing and	Non-manufacturing sectors (only market	Macro economy	IT sectors	Non-IT sectors	Services
56	Other transportation equipment	1	1	1	0	0	1	1	0	0
57	Precision machinery & equipment	1	1	1	0	0	1	1	0	0
58	Plastic products	1	1	1	0	0	1	0	1	0
59	Miscellaneous manufacturing industries	1	1	1	0	0	1	1	0	0
60	Construction	1	1	0	1	1	1	0	1	0
61	Civil engineering	1	1	0	1	1	1	0	1	0
62	Electricity	1	1	0	1	1	1	0	1	1
63	Gas, heat supply	1	1	0	1	1	1	1	0	1
64	Waterworks	1	1	0	1	1	1	0	1	1
65	Water supply for industrial use	1	1	0	1	1	1	0	1	1
66	Waste disposal	1	1	0	1	1	1	0	1	1
67	Wholesale	1	1	0	1	1	1	1	0	1
68	Retail	1	1	0	1	1	1	1	0	1
69	Finance	1	1	0	1	1	1	1	0	1
70	Insurance	1	1	0	1	1	1	1	0	1
71	Real estate	1	1	0	1	1	1	0	1	1
72	Housing	0	0	0	0	0	1	0	0	0
73	Railway	1	1	0	1	1	1	0	1	1
74	Road transportation	1	1	0	1	1	1	0	1	1
75	Water transportation	1	1	0	1	1	1	0	1	1
76	Air transportation	1	1	0	1	1	1	0	1	1
77	Other transportation and packing	1	1	0	1	1	1	0	1	1
78	Telegraph and telephone	1	1	0	1	1	1	1	0	1
79	Mail	1	1	0	1	1	1	1	0	1
80	Education (private and non-profit)	1	0	0	1	0	1	0	0	0
81	Research (private)	1	1	0	1	1	1	0	1	0
82	Medical (private)	1	0	0	1	0	1	0	0	0
83	Hygiene (private and non-profit)	1	0	0	1	0	1	0	0	0
84	Other public services	1	0	0	1	0	1	0	0	0
85	Advertising	1	1	0	1	1	1	1	0	1
86	Rental of office equipment and goods	1	1	0	1	1	1	1	0	1
87	Automobile maintenance services	1	1	0	1	1	1	0	1	1
88	Other services for businesses	1	1	0	1	1	1	1	0	1
89	Entertainment	1	1	0	1	1	1	0	1	1
90	Broadcasting	1	1	0	1	1	1	1	0	1
91	Information services	1	1	0	1	1	1	1	0	1
92	Publishing	1	1	0	1	1	1	1	0	1
93	Video picture, sound information	1	1	0	1	1	1	0	1	0
94	Eating and drinking places	1	1	0	1	1	1	0	1	1
95	Accommodation	1	1	0	1	1	1	0	1	1
96	Laundry, beauty and bath services	1	1	0	1	1	1	0	1	1
97	Other services for individuals	1	1	0	1	1	1	0	1	1
98	Education (public)	1	0	0	1	0	1	0	0	0
99	Research (public)	1	0	0	1	0	1	0	0	0
100	Medical (public)	1	0	0	1	0	1	0	0	0
101	Hygiene (public)	1	0	0	1	0	1	0	0	0
102	Social insurance and social	1	0	0	1	0	1	0	0	0
103	Public administration	1	0	0	1	0	1	0	0	0
104	Medical (non-profit)	1	0	0	1	0	1	0	0	0
105	Social insurance and social welfare	1	0	0	1	0	1	0	0	0
106	Research (non-profit)	1	0	0	1	0	1	0	0	0
107	Other (non-profit)	1	0	0	1	0	1	0	0	0
108	Activities not elsewhere classified	0	0	0	0	0	1	0	0	0

Capital's share (alpha) and labour's share (1-alpha) by industry

Production sector	Alpha	1-Alpha
Rice, wheat production	0.697257981	0.302742019
Miscellaneous crop farming	0.47858163	0.52141837
Livestock and sericulture farming	0.576235734	0.423764266
Agricultural services	0.118579811	0.881420189
Forestry	0.570682432	0.429317568
Fisheries	0.319174371	0.680825629
Mining	0.411126582	0.588873418
Livestock products	0.273020387	0.726979613
Seafood products	0.40985241	0.59014759
Flour and grain mill products	0.525889795	0.474110205
Miscellaneous foods and related products	0.26663936	0.73336064
Prepared animal foods and organic fertilizers	0.507102649	0.492897351
Beverages	0.49074407	0.50925593
Tobacco	0.540961673	0.459038327
Textile products	0.075264117	0.924735883
Lumber and wood products	0.14651516	0.85348484
Furniture and fixtures	0.140447958	0.859552042
Pulp, paper, and coated and glazed paper	0.521668863	0.478331137
Paper products	0.318067531	0.681932469
Printing, plate making for printing and bookbinding	0.214897632	0.785102368
Leather and leather products	0.091710763	0.908289237
Rubber products	0.264946996	0.735053004
Chemical fertilizers	0.568399458	0.431600542
Basic inorganic chemicals	0.594793732	0.405206268
Basic organic chemicals	0.668358452	0.331641548
Organic chemicals	0.579505277	0.420494723
Chemical fibers	0.471823983	0.528176017
Miscellaneous chemical products	0.550817913	0.449182087
Pharmaceutical products	0.637651614	0.362348386
Petroleum products	0.851159415	0.148840585
Coal products	0.672782493	0.327217507
Glass and its products	0.442244326	0.557755674
Cement and its products	0.345159372	0.654840628
Pottery	0.184942228	0.815057772
Miscellaneous ceramic, stone and clay products	0.333585692	0.666414308
Pig iron and crude steel	0.551851048	0.448148952
Miscellaneous iron and steel	0.57257542	0.42742458
Smelting and refining of non-ferrous metals	0.456370006	0.543629994
Non-ferrous metal products	0.447300672	0.552699328
Fabricated constructional and architectural metal products	0.169439022	0.830560978
Miscellaneous fabricated metal products	0.118158917	0.881841083
General industry machinery	0.23062507	0.76937493
Special industry machinery	0.271630302	0.728369698
Miscellaneous machinery	0.162369897	0.837630103
Office and service industry machines	0.337660852	0.662339148
Electrical generating, transmission, distribution and industrial apparatus	0.203737095	0.796262905
Household electric appliances	0.316714067	0.683285933
Electronic data processing machines, digital and analog computer equipment and accessories	0.359916676	0.640083324
Communication equipment	0.268251303	0.731748697
Electronic equipment and electric measuring instruments	0.306636857	0.693363143
Semiconductor devices and integrated circuits	0.394997191	0.605002809
Electronic parts	0.338924254	0.661075746
Miscellaneous electrical machinery equipment	0.326619632	0.673380368
Motor vehicles	0.507014714	0.492985286
Motor vehicle parts and accessories	0.387751552	0.612248448
Other transportation equipment	0.066256962	0.933743038
Precision machinery & equipment	0.228297625	0.771702375
Plastic products	0.285054252	0.714945748
Miscellaneous manufacturing industries	0.186299153	0.813700847
Construction	0.185288154	0.814711846
Civil engineering	0.198986253	0.801013747
Electricity	0.771482276	0.228517724
Gas, heat supply	0.65194328	0.34805672
Waterworks	0.64833897	0.35166103
Water supply for industrial use	0.716157093	0.283842907
Waste disposal	0.216738094	0.783261906
Wholesale	0.329610126	0.670389874
Retail	0.128633668	0.871366332
Finance	0.547326063	0.452673937
Insurance	0.37773357	0.62226643
Real estate	0.659401279	0.340598721
Railway	0.425439234	0.574560766
Road transportation	0.003388179	0.996611821
Water transportation	0.188095606	0.811904394
Air transportation	0.447909583	0.552090417
Other transportation and packing	0.209603766	0.790396234
Telegraph and telephone	0.694041431	0.305958569
Mail	0.26663357	0.73336643
Education (private and non-profit)	0.118577781	0.881422219
Research (private)	0.073408071	0.926591929
Medical (private)	0.360746366	0.639253634
Hygiene (private and non-profit)	0.161616417	0.838383583
Other public services	0.239260867	0.760739133
Advertising	0.308158176	0.691841824
Rental of office equipment and goods	0.720917246	0.279082754
Automobile maintenance services	0.202655413	0.797344587
Other services for businesses	0.097953539	0.902046461
Entertainment	0.554825711	0.445174289
Broadcasting	0.511348754	0.488651246
Information services and internet-based services	0.253184038	0.746815962
Publishing	0.171423629	0.828576371
Video picture, sound information, character information production and distribution	0.158210455	0.841789545
Eating and drinking places	0.214787246	0.785212754
Accommodation	0.323902658	0.676097342
Laundry, beauty and bath services	0.196315388	0.803684612
Other services for individuals	0.196484421	0.803515579
Education (public)	0.148374817	0.851625183
Research (public)	0.042596333	0.957403667
Medical (public)	0.192580747	0.807419253
Hygiene (public)	0.022870378	0.977129622
Social insurance and social welfare (public)	0.041011185	0.958988815
Public administration	0.310561084	0.689438916
Medical (non-profit)	0.300343386	0.699656614
Social insurance and social welfare (non-profit)	0.06509977	0.93490023
Research (non-profit)	0.038892643	0.961107357
Other (non-profit)	0.04184498	0.95815502