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Lean Production System and Economic Development across the World Today

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Abstract

The role of organizational technological innovations in economic development is empirically examined in this paper. The recent inventory trends since the 1980s have two interesting characteristics at the macro-level. First, the inventories have been declining over time. Second, the developed countries have smaller changes in inventories than that of the developing. At the firm-and-industry level, previous studies identify this recent trends in the context of modern production systems such as *just-in-time and lean production* as one source of economic growth especially for the case of developed countries. However, this phenomenon has highlighted less at the country level. Thus, we highlight the nexus between these recent inventory trends and economic growth which leads us to the following hypothesis: the long term declining trend of inventories ratio either over GDP or total capital investment exerts a significantly positive impact on economic development. By using 31 years of relevant panel data of 88 and up to 152 countries and by using panel data econometric techniques, we find that there exists a robust positive relationship between reduction and smaller changes in inventories and economic growth (GDP per capita growth) and economic development (GDP per capita level) across the globe.

Keywords: Lean production; Organizational innovation; Economic development; Inventories trends

JEL codes: O14; O57; L00; D20; E22

Introduction

The study of inventory in macro-economic context has been revived recently through a series of theoretical and empirical articles [1-3]. The general conclusion of these studies is that the long term trend of inventories to GDP ratio has been steadily decreasing since the 1980s although fluctuations still persist. However, there has not been as yet a comprehensive empirical study of the relationship between these recent decreasing trends of inventories to macro-economic growth. Consequently, our aim is to show that this decreasing trend is linked with higher economic growth, levels of economic development, and productivity; this linkage is detected by considering a larger sample of countries or using different sub-sample classified by the level of development. To identify this relationship robustly we use several panel data econometric techniques such as Fixed Effects, GMM, and Hausman-Taylor models.

With these techniques, especially GMM, and by using growth rates as our main dependent variable and the inventories to sales (GDP or total capital investment) as a major interest variable included in the set of explanatory variables, we intend to bring empirical evidence that growth rates are significantly influenced by inventory ratios. As far as we know this is the first comprehensive attempt to bring such evidence on a macro scale (i.e. on a country basis). As a corollary of this attempt is to confirm the above-mentioned decreasing trend of the inventories ratio in our panel data econometric study by examining the coefficient of the explanatory variable of the inventories ratio in the growth model: if this coefficient is as we expect negative and significant then there is a robust evidence that many countries in the world manage their inventories in such a way as to decrease the inventories to sales ratio. We then also bring qualitative evidence via the review of some recent articles that such a change or improvement in inventory management is due to the implementation of new production systems[1].

[1]Some authors like Chikan and Kovacs [8] suggest also globalization (or production network) as a possible factor affecting the decreasing trend of inventories ratios. As a result of this suggestion, in our empirical analysis we include the variables of trade openness and FDI as proxies for globalization.

Effectively, it is well known that the mass production system that took place in the USA during the second industrial revolution during the period of approximately 50 years from 1870 to 1920 has been gradually replaced by modern manufacturing[2] techniques which started with Toyota in Japan since the 1960s. By the first decade of the 21st century, there is evidence (see section 2) that many countries in the world, especially advanced ones, are using modern techniques of technology and organization usually termed under the umbrella of flexible production: just-in-time (JIT) and quality control, lean production, and so on. A prolific literature covers all these historical developments in journals and books in various disciplines. Thus, in economics, Milgrom and Roberts [3] in their pioneering article[3] have already stated that "…Manufacturing is undergoing a revolution. The mass production model is being replaced by a vision of a flexible multiproduct firm that emphasizes quality and speedy response to market conditions while utilizing technologically advanced equipment and new forms of organization…"

Thus, the gradual adoption of new production systems which we will collectively call lean production systems (LPS) has improved the management of inventories on a micro and macro basis and hence as more and more firms become "leaner" in their functioning, their inventories to sales ratio decreases over a long period of time. As

[2]We mean both manufacturing and services, but we will use the term manufacturing or production system for simplicity.

[3]Milgrom and Roberts (1995), Milgrom *et al*. (1991) complement and expand Milgrom and Roberts's (1990) pioneering article.

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more and more firms become leaner, also countries become leaner in production. Consequently, indirectly, the aim of our paper is also to provide empirical evidence as to whether our sample of 88 countries' modernization of their economies by adopting in various degrees principles of the LPS, which entail lower inventories through time, is compatible with higher growth and development[4]. Hence, we include in a standard macro-economic growth model the variable inventories to GDP (or total capital investment) ratio, which is a good proxy for LPS. The coefficient of this variable should be significantly negative (the higher the level of development the lower the inventories ratio (or changes in inventories) in the context of panel data[5]); in this way we also show that the consequences of using LPS adoption (economic growth) in various groups of countries by the level of development.

There is considerable empirical evidence that on a micro basis, firms and industries, through adopting LPS or similar production systems saw their inventories decreasing over a long period of time, thus independently from business cycles fluctuations, hence confirming the theoretical findings of the already examined seminal papers by Milgrom and Roberts as well as more recently Iacoviello et al.

From existing literature, we can find many empirical evidence of the inventories behavior on different levels of analysis. On a micro basis, Chen et al. [4] found that American companies reduced inventories between 1981 and 2000 (See also Chen et al. [5] for an extension of this conclusion to retail and wholesale industries). Bo [6] has found that inventory stock is negatively associated with fixed investment for Dutch firms. On a macro basis, on the other hand, not many studies has highlighted for this recent trends except for Chikan et al. [7], Chikan and Kovacs [8], and Williams [9]. They have empirically shown that inventories to GDP ratio decreases over time for some selected OECD countries, and they refer to the LPS in order to explain this decrease. However, these studies in general use the inventories ratio as a dependent variable and not in the context of macroeconomic growth, although they relate inventories to several other variables.

In section 2 we review and present relevant literature which examines the links between new production systems and inventories. In section 3 we present our econometric modeling, data, variables and proxies. In section 4 we provide our econometric results; there we will use panel data econometric techniques such as fixed effects, GMM, and the Hausman-Taylor model with our dependent variable being the growth rate in GDP per capita, GDP per capita level, and labor productivity level; we will include a comprehensive sample of countries and sub-samples. In section 5 we conclude.

Modern production systems and inventories

This section attempts to relate the long term declining trend in the inventories ratio since approximately the 1980s to modern production systems. We can only infer such a relationship by examining some very relevant articles in the literature; we see this relationship as the most probable explanation of this trend; thus, it is like an assumption we make in our study. We confirm this assumption by our robust empirical evidence that declining inventories ratios are positively related to economic growth across many countries.

A series of empirical findings by Chikan et al. has recently re-examined the behavior of inventories on a macro basis and found that since the 1980s this behavior has changed: the trend steadily decreased and rather did not follow anymore the traditional view that inventories do not alter significantly in the long term. These authors provide two possible reasons for this significant change: the introduction and proliferation of new production systems ("…new management, organization or technological innovations…"; [8] and globalization and hence reduced inventories in developed countries may show up in the so called low cost countries. In this section we review some other related articles which conclude in a similar way that new production systems seem to be the cause of this new decreasing trend in the inventories ratios. As to the globalization issue we will bring empirical evidence that it might play its role as well.

Macro-economic growth depends on micro-economic growth through the existence of major production systems which are more related to micro-economic considerations. Thus, in economic history, scholars usually have related economic development to the following production systems: the craft system mainly in Middle Ages, the factory system mainly during the first industrial revolution in the UK, the mass production system mainly during the second industrial revolution in the USA, and the lean (or flexible, or modern, or just-in-time related, etc) production system which started in Japan after World War II and has been spreading around the world since then. Each one of these systems organized labor, capital and other factors of production in a different way and hence the consequences of such organization have been different in each case in terms of economic growth, labor productivity, waste, inefficiencies, and so on. Therefore, for each one of these systems the overall technology is different (for the more precise relationship between modern production systems and technology. Technology here is taken to represent both technical and organizational innovations, or in general process innovations [10-12]. In the last 30 years the lean production system has received a huge attention and therefore has been analyzed accordingly for its advantages over the other production systems [13].

Theoretical Background about Decreasing Inventories

Theoretically, we will refer mainly to several leading and pioneering papers in the literature in order to examine the close theoretical relationship between modern production systems and decreasing trends in inventories ratios. First, Milgrom and Roberts have shown through mathematical models of 'complementarities' that "…one expects to see a pattern of the following sort linking changes in a wide range of variables: lower prices, lower marginal costs, more frequent Product Redesigns and Improvements, higher Quality in Production, Marked by Fewer Defects, speedier Communication with Customers and Processing of Orders, more Frequent Setups and Smaller Batch Sizes, with Correspondingly Lower Levels of Finished-Goods and Work-In-Process Inventories and of Back Orders per Unit Demand, speedier Delivery from Inventory, lower Setup, Wastage, and Changeover Costs, lower Marginal Costs of Product Redesign..." The complementarities between all these variables are due to indivisibilities and hence non-convexities. As these authors mention (ibid, p. 515) "these non-convexities then explain why the successful adoption of modern manufacturing methods may not be a marginal decision". As these authors conclude, due to these complementarities the expected trend would be "to find an increasing proportion of manufacturing

[4]Although our dependent variable is growth of GDP per capita, "development" is here included because of the following reasons: (i) The LPS/JIT is a holistic paradigm related to many parts of society such as labor relations, way of thinking, and so on (see for example Sanidas, 2005); (ii) we also included more society-oriented variables such as institutional characteristics; and (iii) we distinguish three groups of countries according to their overall development in our regression analysis.

[5]This context of panel data is important because we can combine the time trends for each country with individual characteristics of each one of these countries. Thus it is this combination of time series and cross section that will reveal the inherent mechanisms we seek in our analysis.

firms adopting the modern manufacturing strategic cluster that we have described" (ibid, p. 527). Overall, Milgrom and Roberts (ibid) show that theoretically we should expect a continuous decrease in inventories that takes place in a parallel way along changes in their other variables mentioned above by adopting modern production systems which can be related to many aspects of production. Thus, Holweg [14] clearly shows the genealogy of lean production (LPS) with other modern production systems, such as just in time (JIT); or Powell et al. [15] who link LPS with enterprise resource planning systems; or Winkler and Seebacher [16] who talk about manufacturing flexibility; and so on.

Second, for a very comprehensive and recent treatment of input and output inventories behavior in a general equilibrium macro-economic model, we can now briefly examine the article of Iacoviello et al. These authors relate the importance of LPS and JIT/QC in contributing to the persistent decline of input inventories to GDP ratio through time. It is worth summarizing these authors' findings here because they provide strong theoretical and empirical evidence for our arguments. These scholars have constructed a dynamic stochastic general equilibrium model that takes into account both input and output inventories, both goods and services sectors, depreciation, and other desirable features of a comprehensive model. Input inventories (which are materials and work-in-progress and constituting about 75% of total inventories) are very countercyclical, contrary to output inventories which are mildly procyclical. As clearly shown in their graphs the input inventories to GDP ratio has been steadily declining since about the mid-1980s in the USA. Through Bayesian estimation methods, Iacoviello et al. successfully capture the counter-cyclicality and declining trend of the input inventory to output ratio; and through their general equilibrium model, the authors derive the steady-state ratios of input and output inventories ratios which are a function of several parameters such as the weight of input inventories in the CES aggregate, the elasticity of substitution, and so on. These parameters are determined by "... new methods of inventory management like just-in-time production or flexible manufacturing system..." (ibid, p. 1184) which have been eminent since 1984. As the authors emphasize (ibid, p. 1192), "...the prevailing view in the literature is that a decline in $(M+F)/Y_g$ or M/Y_g likely resulted from improvements in inventory management and production techniques, such as "just-in-time" production, "flexible manufacturing systems", and "material resources planning"..." (M and F stand for input and output inventories respectively; Y_g stands for GDP)[6].

Third, in more concrete terms we can also refer to the production smoothing as seen in LPS and JIT systems. The objective of this smoothing "…is to reduce the variability of the production rate at the final stage of manufacturing operations so as to create a stable demand stream for the other manufacturing operations at the preceding stages. Therefore, production smoothing is a key element of TPS (Toyota production system), and, hence, a key component of the JIT philosophy…" [17]. Many techniques have been devised in order to achieve production smoothing and hence efficient inventories planning within the context of LPS and JIT as Yavuz and Akcali show in their article. Although production smoothing primarily examines volatility or variance of production, it is nonetheless important to link production smoothing to inventories and their trend to diminish over time [18,19]. Thus, Morton et al. conclude that subcontracting (a special feature of JIT) reduces the variability of production and inventory. It is worth noting that Wen [20] showed that "…under the production smoothing motive, the covariance between inventory investment and sales is negative at all cyclical frequencies…" This, supports the main consequence of the LPS cum JIT structures that as the sales increase in the long term, inventories decrease[7]. Fourth, Bils and Kahn [21] have shown that "...a persistent rise in real marginal cost, absent intertemporal substitution, creates a persistent reduction in inventory holdings relative to expected shipments". Finally, the study by Brox and Fader [22] is also worthwhile mentioning because it clearly shows the efficiency superiority of JIT firms (in relation to non-JIT firms) by relating output, costs and inventories amongst other variables.

Implementation of LPS in the world

On a country basis there is substantial evidence that the penetration of modern production systems or LPS as we call it here is increasing all over the world. In general, the more advanced a country is the more it prefers to use LPS. Thus, for example, Demeter and Matyusz [23] surveyed 610 firms in 23 countries around the world. Out of these 610, 330 reported being "lean" (LPS), which represents a 54% of penetration in total (although the large firms reported a higher "leanness" than SMEs, that is 67%). In this survey, 14 countries are European; also Argentina, Australia, Brazil, Canada, China, Israel, New Zealand, the USA, and Venezuela are included. In a recent study of 28 European countries by Holm et al. [24] in terms of work organization, on average, about 64% might be considered as belonging to LPS (we added the total average of the first two columns of these authors' Tables 1 and 2).

For the USA, a study by White et al. [25], showed that for a sample of 474 firms (either very large, employing more than 1000 people; or SMEs, employing less than 250 people), the penetration of LPS was already very high: concerning 10 "lean" practices, the implementation ranged from 91.4% for large firms (82.2% for SMEs) for the practice of total quality control, to 81.8% for large firms (66.1% for SMEs) for JIT purchasing; and so on. A comparative study by Phan and Matsui (2010, p. 190) showed that "…JIT production was aggressively implemented in Korean and US plants while it was not so focused in German and Italian plants. In between those is Japan where JIT production has been adopted earlier than other countries…" Overall, we have found articles of LPS implementation for almost all countries[8] in our sample, but an exhaustive examination of these articles is out of scope of the present paper.

Empirical Model, Data, and Variables

Empirical model

Our starting point is the standard growth model that has been extensively used in the last 20 years or so since the seminal studies by Mankiw et al. [26], Barro and Sala-I-Martin [27,28], Islam [29], Barro and Sala-i-Martin [27], Silva and Teixeira [30]. We can summarize their modeling relevant to our study as follows. A basic Cobb-Douglas production function can take the form:

$$Y(t) = K(t)^{\alpha}H(t)^{\beta}[A(t)L(t)]^{1-\alpha-\beta} \quad (1)$$

where: *Y* is output; *K* is physical capital stock; *H* is the stock of human capital; *L* is labor; *A* represents the level of technology in general; and *t* is time.

It is important to stress the meaning and importance of the term 'A' which is defined not only in the narrow sense of production technology, but it also includes resource endowments, institutions, etc. Islam clearly shows that "…higher values of 'A' are associated not only with higher

[6]The authors then quote several papers related to this statement.

[7]Wen (2005) did not have in mind these structures of LP and JIT, but it is not unreasonable to deduce the above conclusion from his proposition.

[8]This literature is available on request.

Variable Description	Name	Obs.	Mean	Std.	Min	Max
Real GDP per capita Growth Rate (annual%)[a]	RGGR	477	1.75	3.37	-19.59	12.43
Log of Real GDP per-capita (initial year)[b]	LNRGPC_INI	471	8.31	1.59	5.30	10.80
Log of Gov't Consumption (% of GDP)[a]	LNGC	466	2.72	0.39	0.46	3.65
Log of Investment (% of GDP)[a]	LNI	468	3.11	0.29	1.62	4.21
Population Growth[a]	POPG	504	1.23	1.14	-2.10	5.91
Log of Openness (Trade/GDP)[a]	LNOP	466	4.20	0.55	2.21	6.05
Log of Secondary Schooling (% of total enrollment)[a]	LNSSE	474	4.19	0.55	2.33	5.05
Log of Foreign Direct Investment (Inward FDI/GDP)	FDI	474	4.54	26.5	-1.02	432.34
Inflation, consumer prices (annual%)[a]	INFP	446	35.7	231	-1.83	2769
Institutional Quality Index[c]	INS	496	0.49	0.98	-1.36	1.85
R&D expenditure (% of GDP)[c]	RAD	456	1.17	1.07	0.04	4.18
ΔInventories Ratio to GDP (one-year lag)[d]	IRG_L1	451	1.03	3.54	-25.59	31.39
ΔInventories Ratio to GDP (two-year lag)[d]	IRG_L2	450	1.07	3.72	-19.10	32.11
ΔInventories Ratio to GDP (three-year lag)[d]	IRG_L3	397	1.09	3.59	-23.54	31.25
ΔInventories Ratio to Investment (one-year lag)[d]	IRI_L1	446	0.04	0.29	-2.37	5.09
ΔInventories Ratio to Investment (two-year lag)[d]	IRI_L2	444	0.03	0.28	-2.33	4.58
ΔInventories Ratio to Investment (three-year lag)[d]	IRI_L3	393	0.03	0.26	-2.35	4.06

Notes: Data from the World Bank's WDI (World Development Indicators) and WGI (Worldwide Governance Indicators)

[a]Calculated using average of non-overlapping four-year periods (1981-2008).

[b]Initial year for each one of the 7 periods (1981, 1985, 1989, 1993, 1997, 2001 and 2005).

[c]Calculated using average of 10-years (1999-2008) due to lack of data.

[d]Calculated using averages of non-overlapping four-year periods (1980-2007 for a one-year lag, 1979-2006 for a two-year lag, and 1978-2005 for a three-year lag). For the 5-year average data (not shown here) the non-overlapping periods are adjusted accordingly.

Table 1: Descriptive Statistics of variables (for the 4-year average data).

Country List	Group	IRG (ΔInventories/GDP)				IRI (ΔInventories/GCF)			
		Mean	S.D	Min	Max	Mean	S.D	Min	Max
Angola	G1	-3.74	7.32	-14.59	0.75	-0.27	0.56	-1.10	0.06
Argentina	G2	15.98	5.24	9.06	21.32	0.04	.	0.04	0.04
Armenia	G1	0.94	0.90	-0.44	1.98	-0.57	1.38	-3.04	0.10
Australia	G3	0.28	0.12	0.13	0.50	0.01	0.00	0.00	0.02
Austria	G3	0.75	0.51	0.10	1.82	0.03	0.02	0.00	0.07
Belarus	G2	2.50	2.22	-0.01	6.00	0.08	0.08	0.00	0.21
Belgium	G3	1.12	1.11	0.11	3.39	0.05	0.04	0.00	0.13
Bolivia	G1	0.66	0.81	-0.20	1.97	0.03	0.05	-0.01	0.12
Brazil	G2	0.37	0.47	-0.70	0.75	0.02	0.03	-0.04	0.04
Bulgaria	G2	4.08	3.04	-1.77	7.09	0.11	0.15	-0.24	0.21
Cameroon	G1	-0.05	3.70	-8.33	4.56	0.01	0.13	-0.27	0.18
Canada	G3	0.25	0.49	-0.53	0.75	0.01	0.02	-0.03	0.04
Chile	G2	1.20	1.04	0.06	3.47	0.05	0.06	-0.05	0.16
China	G2	5.36	2.68	1.95	8.91	0.14	0.07	0.05	0.24
Colombia	G2	7.05	8.75	1.61	23.74	0.09	0.04	0.02	0.14
Costa Rica	G2	0.65	1.97	-1.87	4.14	0.01	0.10	-0.13	0.16
Cote d'Ivoire	G1	0.30	0.84	-1.51	1.05	0.00	0.09	-0.21	0.06
Croatia	G3	2.29	0.54	1.67	2.97	0.10	0.05	0.07	0.17
Cyprus	G3	1.92	1.28	0.35	3.69	0.07	0.04	0.02	0.12
Czech Republic	G3	0.63	0.88	-0.78	1.52	0.02	0.03	-0.03	0.06
Denmark	G3	0.58	0.25	0.32	0.98	0.03	0.01	0.01	0.04
Ecuador	G2	1.09	1.20	-0.62	2.33	0.04	0.05	-0.03	0.10
Egypt, Arab Rep.	G1	0.87	1.08	0.08	3.46	0.03	0.04	0.00	0.11
El Salvador	G1	0.42	0.51	-0.54	1.00	0.02	0.03	-0.05	0.06
Estonia	G3	2.56	1.45	1.51	5.36	0.08	0.05	0.06	0.19
Finland	G3	0.70	0.67	-0.22	1.77	0.03	0.03	-0.02	0.07
France	G3	0.38	0.42	-0.27	1.09	0.02	0.02	-0.02	0.05
Gabon	G2	0.31	1.03	-1.42	1.62	0.01	0.03	-0.04	0.05
Georgia	G1	14.34	13.22	0.59	30.92	0.18	0.11	0.02	0.28
Germany	G3	0.17	0.60	-0.61	1.39	0.01	0.03	-0.03	0.06
Ghana	G1	0.12	0.32	-0.12	0.79	0.00	0.02	-0.02	0.03
Greece	G3	-1.11	8.91	-22.21	7.97	0.63	1.15	-0.09	2.91
Guatemala	G1	0.76	0.51	0.12	1.69	0.04	0.03	0.00	0.08
Honduras	G1	2.71	2.45	-1.45	7.25	0.09	0.09	-0.11	0.22
Hong Kong SAR, China	G3	1.20	0.98	-0.01	2.64	0.04	0.03	0.00	0.08

Hungary		G3	2.81	0.91	1.71	4.58	0.10	0.03	0.04	0.16
Iceland		G3	0.17	0.35	-0.40	0.66	0.01	0.01	-0.02	0.02
India		G1	1.90	1.15	0.60	4.31	0.07	0.04	0.02	0.11
Indonesia		G1	3.27	3.55	-2.90	9.63	0.06	0.14	-0.27	0.15
Iran, Islamic Rep.		G2	2.59	6.91	-7.99	11.93	0.02	0.26	-0.47	0.23
Ireland		G3	0.58	0.36	0.18	1.09	0.03	0.02	0.01	0.05
Israel		G3	0.86	0.76	0.17	2.26	0.04	0.03	0.01	0.09
Italy		G3	0.28	0.29	-0.40	0.58	0.01	0.01	-0.02	0.03
Japan		G3	0.36	0.19	0.06	0.59	0.01	0.01	0.00	0.02
Kazakhstan		G2	1.28	2.04	-1.53	3.80	0.04	0.08	-0.09	0.11
Korea, Rep.		G3	0.52	0.76	-1.25	1.20	0.01	0.03	-0.05	0.04
Latvia		G2	4.73	6.43	0.22	19.59	0.14	0.20	-0.05	0.52
Lithuania		G2	0.15	1.45	-2.05	1.89	-0.02	0.08	-0.11	0.07
Luxembourg		G3	1.22	2.07	-2.73	4.38	0.05	0.10	-0.16	0.17
Macedonia, FYR		G2	2.41	2.52	-1.66	4.40	0.11	0.13	-0.11	0.20
Malaysia		G2	-0.39	0.93	-2.02	0.75	-0.01	0.04	-0.09	0.03
Malta		G3	0.84	1.63	-2.77	2.77	0.02	0.08	-0.17	0.09
Mexico		G2	3.12	1.26	1.50	4.83	0.13	0.05	0.07	0.21
Mongolia		G1	3.25	0.77	2.41	4.25	0.08	0.02	0.07	0.12
Morocco		G1	0.97	0.62	-0.05	1.78	0.04	0.02	0.00	0.06
Namibia		G2	0.94	1.95	-1.64	4.09	0.01	0.11	-0.21	0.14
Netherlands		G3	0.10	0.30	-0.33	0.69	0.00	0.01	-0.02	0.03
New Zealand		G3	0.73	0.49	-0.03	1.29	0.03	0.02	0.00	0.06
Nicaragua		G1	1.25	2.61	-4.03	5.31	0.16	0.23	0.01	0.71
Norway		G3	0.92	1.20	-1.13	2.18	0.04	0.05	-0.04	0.09
Pakistan		G1	1.55	0.35	0.77	1.92	0.08	0.02	0.04	0.11
Panama		G2	2.63	2.06	-0.54	5.13	0.11	0.09	-0.06	0.22
Paraguay		G1	1.59	0.71	0.61	2.87	0.07	0.03	0.03	0.12
Peru		G2	1.03	0.75	-0.07	2.38	0.04	0.02	0.00	0.07
Philippines		G1	0.62	1.55	-0.73	4.29	0.02	0.05	-0.04	0.14
Poland		G3	2.94	3.15	0.35	7.46	0.10	0.09	0.02	0.25
Portugal		G3	0.64	0.42	0.34	1.63	0.02	0.01	0.01	0.05
Romania		G2	3.54	4.74	-0.50	12.11	0.12	0.18	-0.03	0.41
Russian Federation		G2	3.64	2.14	1.19	6.80	0.14	0.06	0.05	0.19
Saudi Arabia		G3	1.24	1.82	-1.95	3.77	0.04	0.08	-0.11	0.11
Senegal		G1	-3.38	3.95	-8.04	1.60	-0.29	0.35	-0.80	0.09
Serbia		G2	2.55	3.28	-0.73	5.83	0.10	0.20	-0.10	0.30
Singapore		G3	0.56	2.73	-3.62	5.24	0.00	0.10	-0.19	0.12
Slovak Republic		G3	1.86	3.79	-2.20	8.57	0.02	0.07	-0.11	0.10
Slovenia		G3	0.78	1.67	-1.90	2.70	0.02	0.08	-0.11	0.09
South Africa		G2	0.49	0.81	-1.09	1.16	0.02	0.04	-0.06	0.07
Spain		G3	0.43	0.36	-0.09	1.03	0.02	0.02	0.00	0.04
Sri Lanka		G1	0.73	0.83	0.01	2.41	0.03	0.03	0.00	0.09
Sweden		G3	0.26	0.32	-0.39	0.57	0.01	0.02	-0.02	0.03
Switzerland		G3	0.53	0.64	-0.02	2.01	0.02	0.02	0.00	0.07
Thailand		G2	0.85	0.64	-0.38	1.97	0.03	0.03	-0.02	0.07
Tunisia		G2	1.03	0.70	-0.11	2.01	0.04	0.03	0.00	0.08
Turkey		G2	0.29	0.78	-0.37	1.97	0.01	0.05	-0.02	0.12
Ukraine		G1	2.74	3.37	0.00	7.29	0.09	0.10	0.00	0.22
United Kingdom		G3	-1.43	4.75	-13.18	0.60	0.00	0.03	-0.06	0.03
United States		G3	0.43	0.22	0.12	0.75	0.02	0.01	0.01	0.04
Uruguay		G2	1.19	0.91	0.19	2.84	0.07	0.05	0.02	0.14
Uzbekistan		G1	-3.62	5.32	-9.75	3.45	-0.20	0.26	-0.51	0.14
Venezuela, RB		G2	1.37	1.84	-1.33	3.85	0.03	0.10	-0.15	0.15
Vietnam		G1	7.04	5.47	1.88	15.28	0.08	0.02	0.06	0.10
Average	G1		1.68	4.85	-9.75	30.92	0.01	0.28	-3.04	0.71
	G2		2.22	3.96	-7.99	23.74	0.06	0.10	-0.47	0.52
	G3		0.74	2.13	-22.21	8.57	0.05	0.21	-0.19	2.91
	(G1+G2+G3) (for 88 countries)		1.99	5.61	-38.35	58.12	0.06	0.36	-3.04	10.03

Note: the initial data of national inventories and GDP were such that the ratio of IRG should be divided by 100 in order to be compatible with the IRI ratio in this table.

Table 2: Descriptive statistics on IRI and IRG (4-year average) by country and group.

levels of per capita income, but also with higher growth rates". This is an important conclusion in econometric work, because we can use growth rates or levels in GDP per capita in order to measure the effect of 'A' and expect a positive relationship in both cases. In addition, as Islam [29] also shows, the endogenous character of technology 'A' can be more safely demonstrated in panel data regressions.

Overall then we can use the following conventional notation of the panel data literature; thus, in level terms[9] we have:

$$y_{it} = \gamma y_{i,t-1} + \sum_{j=1}^{n} \beta_j x_{it}{}^{j} + \eta_t + \mu_i + \varepsilon_{it} \quad (2)$$

Where η_t is a time variant error term; μ_i (which is a function of A) is the time-invariant individual country-effect term in a panel data set up, and ε_{it} is the transitory error term that varies across countries and time periods and has mean equal to zero.

Simplifying (2) by eliminating the time related term η_t (a usual practice in empirics) and also including more explanatory variables such as the inventories ratios and control variables x_{it} we have the equation (3) below:

$$y_{it}=\alpha_{i,t-1}+\beta x_{it}+\mu_i+\varepsilon_{it} \quad (3)$$

In order to eliminate the unobserved effect μ_i from (3) the first difference generalized method of moments (GMM-difference) estimator was proposed by Arellano and Bond [31]:

$$y_{it}- y_{i,t-1}=\alpha(y_{i,t-1}- y_{i,t-2})+ \beta(x_{it}- x_{it-2})+(\varepsilon_{it}-\varepsilon_{i,t-2}) \quad (4)$$

To eliminate some weak features of GMM-difference Blundell and Bond [32] suggested the GMM-system estimators by using eqns. (3) and (4) together. In particular one advantage of GMM-system is that the potential endogeneity of all explanatory variables can be controlled by appropriate lags and instruments; also another advantage is the superiority in finite sample properties. In addition, as Bond et al. [33] report "…it is not unreasonable to consider the system GMM estimator in the context of empirical growth models…" On the contrary, the same authors found that the first differences GMM estimator does not perform well in this context.

To check for the over-identifying restrictions and of the appropriate instruments, the Sargan [34] or the Hansen [35] tests can be used. The Hansen test is more appropriate in most panel data cases because Sargan's statistic is a special case of Hansen's test under the assumption of homoscedasticity; thus in the case of non-sphericity in the errors (e.g. in the case of heteroscedastic errors) the more general Hansen test should be used [36]. However, one should be careful in using Hansen's test because it can be weakened by too many instruments. Let Roodman [36] summarize this conclusion: "…The Sargan and difference-in-Sargan tests are not so vulnerable to instrument proliferation as they do not depend on an estimate of the optimal weighting matrix. But they require homoskedastic errors for consistency and that is rarely assumed in this context…"

Consequently in our estimated regressions we only report Hansen's test and at the same time endeavored to use as few instruments as possible as well as to use the two step procedure that is robust to heteroscedasticity. In addition, we check the instrument proliferation with the difference-in-Hansen tests which although not reported in our tables of results show that our instruments are used safely. Finally, to check for autocorrelation of residuals the Arellano-Bond AR (2) in first differences test is used. There is no need to report the AR (1) first differences test, because it usually rejects the null hypothesis, but this is expected since $\Delta e_{it}=e_{it}-e_{i,t-1}$ and $\Delta e_{i,t-1}=e_{i,t-1}-e_{i,t-2}$ both have $e_{i,t-1}$. The test for AR (2) in first differences is more important, because it will detect autocorrelation in levels. Again, in the literature in the tables of results, it is customary that only AR (2) is reported.

In summary, we will use three econometric techniques. First, the GMM is perhaps the most adequate method to use as it treats several issues in a comprehensive way: full endogeneity between variables, lags structure, and panel data. Second, the fixed effects (FE) method which controls for unobserved individual country heterogeneity correlated with independent variables but does not treat the issue of full endogeneity properly. Our tables of results do not include any random effects (RE) regressions since the Hausman test confirms our choice of FE as being the right model to use. Finally we also use the Hausman-Taylor method because we include two time invariant variables by necessity (due to lack of data for the whole period), that is, R&D, and institutional quality.

Data and proxies

Except for the institutional variables (they come from World Governance Indicators) all other data come from the World Development Indicators (WDI) database provided by the World Bank. We used the WDI source to determine our sample of countries. This source separates countries in four groups: First, the 'low income economies' with a GNI per capita less than $975 in 2008 (as published in 2010). Middle-income economies are those with a GNI per capita of more than $975 but less than $11,906. In addition, lower middle-income (LMI) and upper middle-income (UMI) economies are separated at a GNI per capita of $3,855. HI (High-income) economies are those with a GNI per capita of $11,906 or more. In our paper we consider the last three groups of nations for estimation purposes and a combination of these three groups (thus excluding the group with less than $975 per capita). Within these three groups (also called G1, G2, and G3 henceforth, with G3 being the richest group) we excluded some countries which are oil producing, at war, or very small (Appendix).

The time span used in these regressions is 31 years (1978-2008)[10] in terms of six periods (by taking 5-year average for each one of the 6 periods) or in terms of 7-8 periods (by taking 4-year average for each one of the 7-8 periods)[11] Thus, average growth rates (and other variables of the regressions) over 5 year periods or 4-year periods were used for robustness checking. As per standard practice we use growth rates of GDP per capita or GDP per capita in level terms or productivity levels as our dependent variable. Our variable of immediate interest is inventories to sales ratio which takes the form of either inventories over GDP (IRG) or inventories over investment (IRI), as will be further explained below, with lags of one or two or three years[12]. Our other independent variables include[13] as per usual practice, the initial per-capita GDP controlling for the effect of the initial level of a country's economic development; investment (as % of GDP), education (secondary schooling); population growth; inflation (thus controlling for macroeconomic policies); trade openness; foreign inward direct investment; R&D, and institutional factors. Table 1 shows some basic

[9]Variables are expressed in logs.

[10]It is wise to use data before the global financial crisis of 2008/9 for obvious reasons (e.g. abnormal decline in GDP, etc.)

[11]This is a usual practice to eliminate the influence of business cycles (see Islam 1995).

[12]The lag is in-built into the average.

[13]A square term of the proxies was initially included but was found insignificant thus suggesting a linear form.

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descriptive statistics of the variables used in our regressions, and more precise definitions.

In our empirical work, we shall proxy the technical and organizational technology embodied in LPS by the inventories to sales ratio. As we have already seen above, although quality increases in tandem with decreasing inventories under the impact of LPS (see for example Alles et al., [37] for links between reducing inventories and increasing quality), we do not have readily available a measure of quality control or improvement on a country basis. On the contrary, the proxy inventories to sales ratio has been already established in literature as a good proxy for the JIT/QC or LPS. In this respect see for example, Lieberman and Demeester [38], Nakamura M. and Nakamura A [39], Biggart and Gargeya [40], Ramey and Vine [41], Bairam [42], Salem and Jacques [43], Capkun et al. [44], Irvine [45], Swamidass [46], Lim and Sanidas [47], Sanidas [48,49], as well as Sanidas and Park [49]. This literature review shows that, on a micro basis there is evidence that inventories to sales ratio has been decreasing over a long period of time (thus independent of business cycles) in many firms and sectors in countries where the LPS has been implemented. However, not all firms and not all sectors experience this decreasing long term trend and hence not all countries experience the same degree of inventories to sales (or GDP) ratio reductions. On a macro basis Chikan, Kovacs and Williams use the same proxy of inventories to GDP ratio.

On a macro basis, we do not have a readily available series of sales in order to construct the inventories ratios. We will then use two alternatives for sales, namely, gross domestic investment and GDP (the latter has been used by many other researchers). We shall call "IRG" the inventories[14] to GDP ratio and "IRI" the inventories to investment ratio, defined as follows:

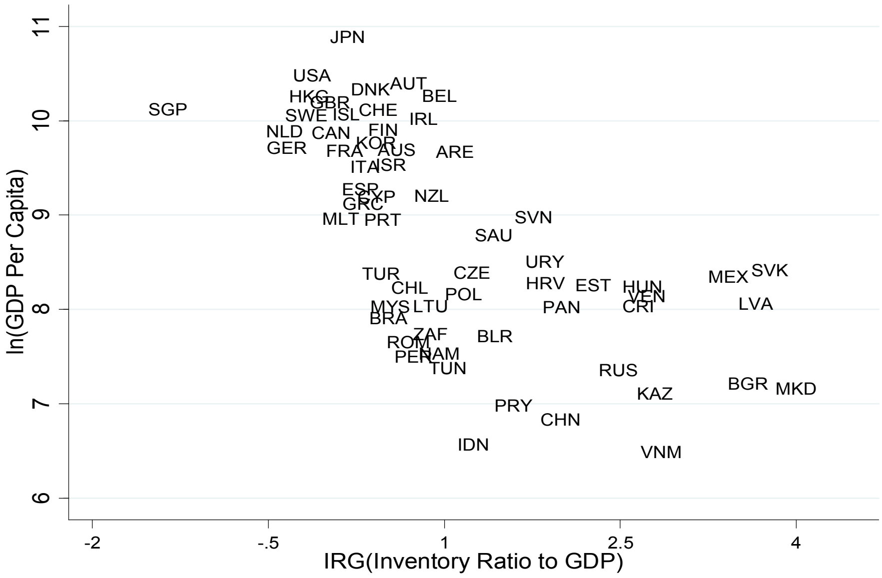
$$IRG_{jt} = \frac{INV_{jt} - INV_{jt-1}}{GDP_{jt}}, and\ IRI_{jt} \frac{INV_{jt} - INV_{jt-1}}{GCF_{jt}}$$

where INV[15] stands for total national inventories, and GCF stands for gross capital formation, the index '*j*' stands for country, and '*t*' stands for year. Some basic descriptive statistics on IRG and IRI for the sample countries are shown in Table 2. An important comment in this table is that more developed countries have the tendency to have a lower inventory ratio to sales as Figure 1 (either Figure1a: IRG or Figure 1b: IRI) also shows, thus confirming our analysis so far.

Figures 2a-2c show the yearly trend of IRG for selected countries such as the developing China, India and Mexico, the Newly Industrialized Economies (S. Korea, Hong Kong and Singapore) and the developed countries (United States, Germany and Japan); Figures 3a-3c show the corresponding trends for IRI. In these Figures we can observe, for example, that even though IRG and IRI seem to be fluctuating along with business cycles, most countries' IRG and IRI have been drifting downwards in the long run; China's IRG has been decreasing even more substantially [50]. However, not all countries show consistently a decreasing trend; thus, Mexico or India's IRI or IRG has been increasing from the early 2000s. Furthermore note that the more developed a country is, the smaller the level of inventories to sales is (thus confirming Figure 1). All these differences in the behavior of inventories ratios between various countries will be taken into account in our panel data econometric analysis [51].

Empirical evidence

First we will examine the GDP per capita growth rates as our dependent variable. Our GMM results are shown in Tables 3a and 3b. Table 3a presents results when IRG (inventories ratio to GDP) is used, whereas Table 3b presents results when the variable IRI is used. In both tables, results are categorized according to the group of countries used in the sample: G3 for the most advanced nations; or G1+G2 for developing and less developing nations; or G1+G2+G3; or all countries. Also in both tables some results are related to the 4-year averages case, and other results are related to the 5-year averages case [52-55]. Finally, all results are categorized according to the lag in-built in IRG or IRI.



Note: based on selected countries and period for 10 years averaged from 1999 to 2008. See abbreviation of country name and its code in the Appendix.

Figure 1a: Relationship between per-capita GDP and IRG.

The endogenous variables used in these GMM regressions are the dependent variable, the inventories to GDP or capital formation ratios (IRG, or IRI), the capital formation to GDP ratio, and sometimes the

[14]Only the change in inventories from year to year is available on a macro basis.

[15]Inventories are raw materials, work-in-progress goods, and final goods held by firms to meet temporary or unexpected fluctuations in production or sales (WDI 2010).

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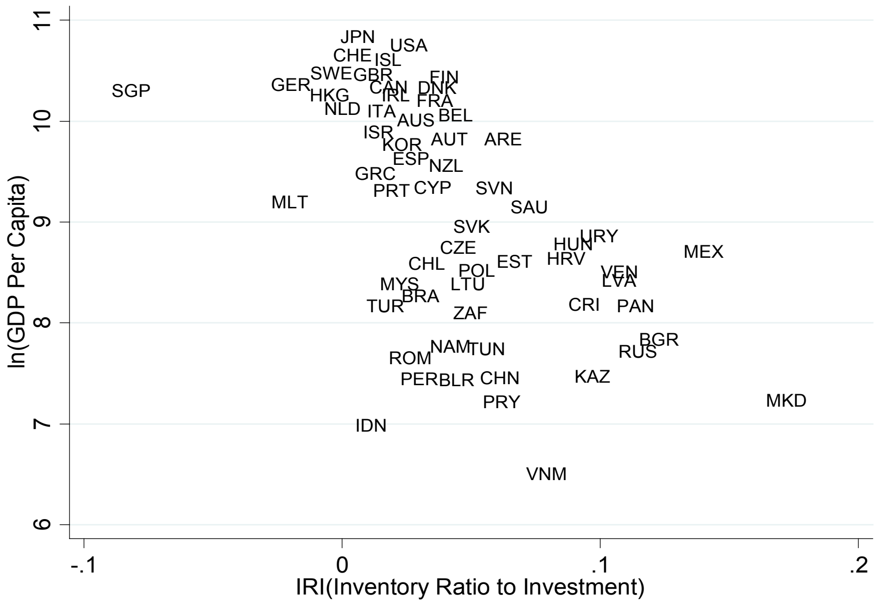

Note: based on selected countries and period for 10 years averaged from 1999 to 2008.

See abbreviation of country name and its code in the Appendix.

Figure 1b: Relationship between per-capita GDP and IRI.

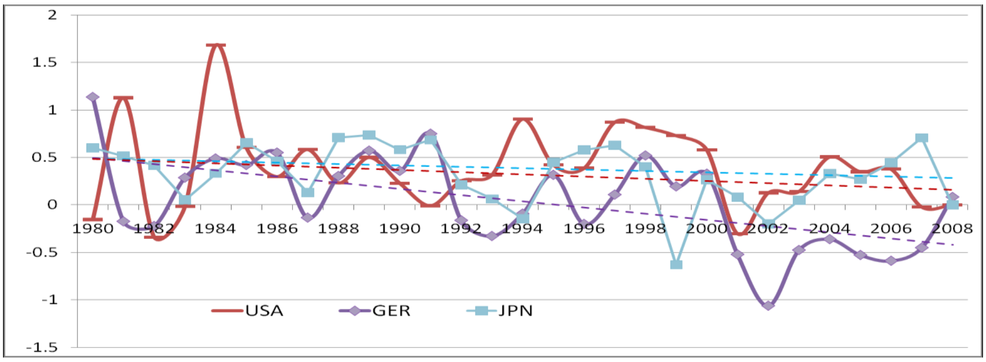

Figure 2a: IRG yearly trends for USA, Germany and Japan.

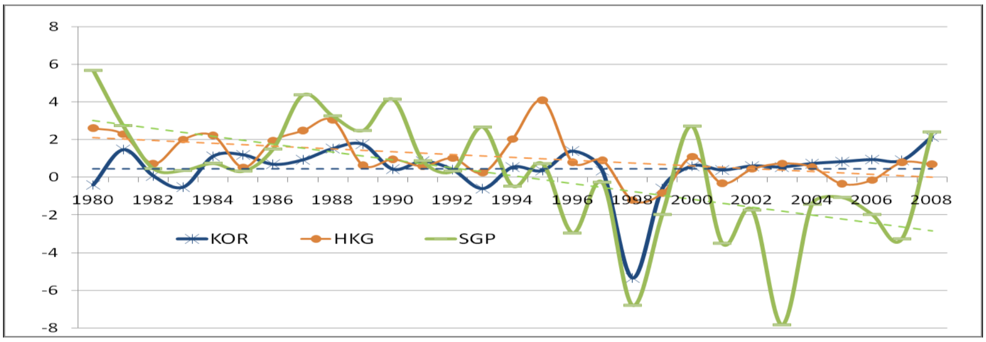

Figure 2b: IRG yearly trends for Korea, Hong Kong and Singapore.

inflation rate representing monetary policy. On the other hand the strictly exogenous variables are the initial level of income at the start of each period, population growth, and the secondary education ratio. A typical lag structure is one to four lags for the dependent variable, IRG or IRI, and inflation rate, whereas it is two to five lags for the capital formation ratio.

All variables have the expected sign and are significant. According to

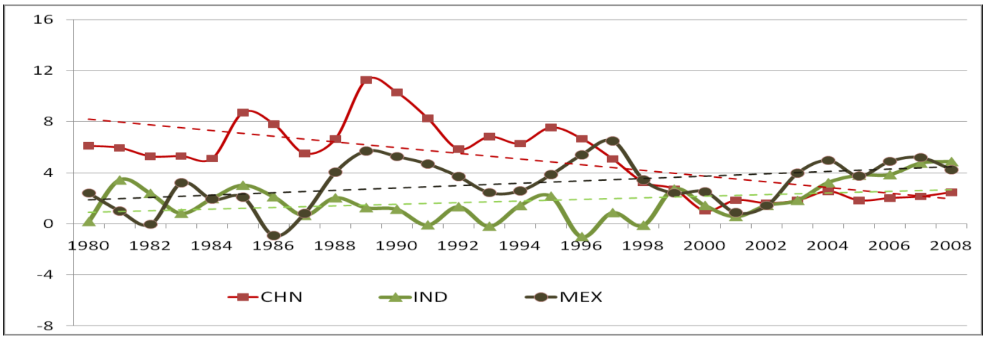

Figure 2c: IRG yearly trends for China, India and Mexico.

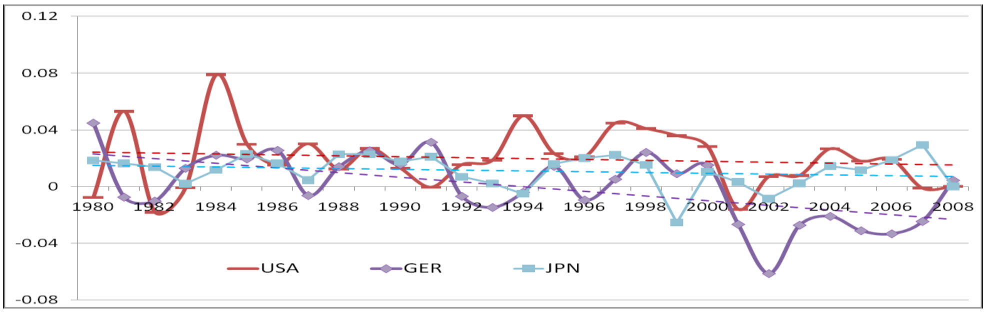

Figure 3a: IRI yearly trends for USA, Germany and Japan.

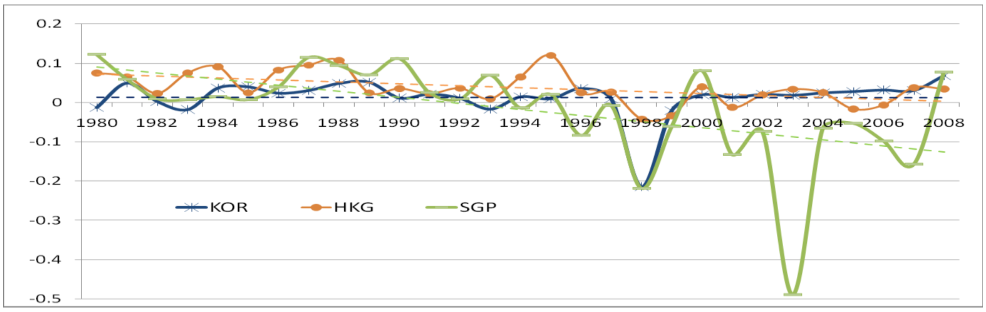

Figure 3b: IRI yearly trends for Korea, Hong Kong and Singapore.

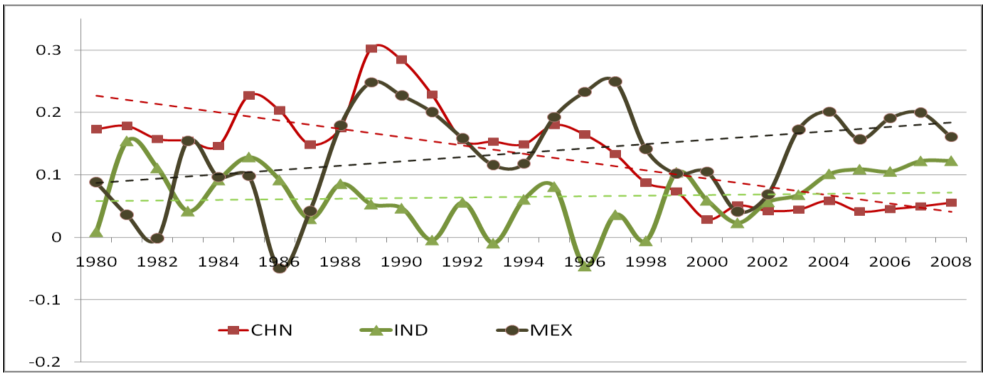

Figure 3c: IRI yearly trends for China, India and Mexico.

existing literature, the signs of GDP per capita initial year, government consumption, population growth, and inflation are expected to be negative as they are in our regressions. On the contrary, the signs of the investment ratio and FDI are expected to be positive as they are in our regressions [56-58]. The signs for education and openness are expected to be also positive but sometimes they are also reported to be negative.

Dependent Variable: Real GDP per capita Growth Rate	**G3**			**G1+G2**				**G1+G2+G3**							**All Countries**
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**	**(13)**	**(14)**	**(15)**
ln(RGPC_INI)	-1.08*** (-9.18)	-0.95*** (-9.78)	-1.13*** (-10.49)	-0.86*** (-11.59)	-0.85*** (-12.74)	-0.85*** (-10.39)	-0.75*** (-7.40)	-0.38*** (-17.86)	-0.46*** (-27.04)	-0.35*** (-14.93)	-0.40*** (-18.74)	-0.43*** (-28.97)	-0.34*** (-17.64)	-0.36*** (-16.73)	-0.22*** (-16.57)
ln(GC)	0.31 (0.79)	-1.46*** (-4.37)	-0.99** (-2.11)	-3.30*** (-15.70)	-3.63*** (-19.39)	-2.63*** (-10.50)	-3.47*** (-16.26)	-3.60*** (-54.24)	-3.39*** (-62.92)	-4.09*** (-34.23)	-3.65*** (-41.55)	-3.77*** (-52.36)	-4.19*** (-51.99)	-4.13*** (-33.55)	-2.83*** (-83.55)
ln(I)	3.11*** (11.27)	2.46*** (5.06)	2.12*** (5.80)	3.85*** (9.98)	4.19*** (24.98)	4.17*** (16.06)	4.17*** (16.69)	2.93*** (95.19)	3.54*** (64.94)	4.01*** (87.55)	3.65*** (36.96)	3.81*** (49.71)	3.73*** (104.90)	4.13*** (92.55)	2.93*** (90.56)
POPG	-0.40*** (-5.85)	-0.28*** (-3.66)	-0.30*** (-3.51)	-0.58*** (-8.52)	-0.66*** (-9.94)	-0.48*** (-8.47)	-0.61*** (-7.78)	-0.36*** (-47.70)	-0.34*** (-35.83)	-0.46*** (-33.07)	-0.43*** (-39.73)	-0.45*** (-31.72)	-0.44*** (-60.80)	-0.45*** (-53.10)	-0.40*** (-41.78)
ln(OP)	0.36** (1.44)	0.50*** (3.37)	0.57** (2.05)	0.17 (0.62)	-0.03 (-0.13)	-0.07 (-0.24)	-0.27 (-1.33)	0.02 (0.36)	0.17*** (3.58)	-0.03 (-0.62	0.11** (2.08)	0.03 (0.49)	0.11* (1.80)	0.01 (0.17)	1.04*** (48.17)
ln(SSE)	2.56*** (5.28)	2.79*** (9.12)	2.33*** (3.76)	1.60*** (5.51)	1.53*** (6.54)	1.36*** (6.61)	1.80*** (6.04)	2.08*** (64.77)	2.25*** (78.77)	1.96*** (35.17)	1.94*** (28.34)	2.04*** (51.09)	1.90*** (40.89)	1.96*** (38.20)	0.32*** (15.63)
INFP	-0.03*** (-4.77)	-0.02*** (-6.62)	-0.02*** (-3.40)	-0.01*** (-31.45)	-0.01*** (-24.93)	-0.01*** (-17.99)	-0.01*** (-20.56)	-0.01*** (-261.39)	-0.01*** (-227.1)	-0.003*** (-298.5)	-0.003*** (-440.2)	-0.003*** (-255.3)	-0.003*** (-297.11)	-0.003*** (-423.7)	-0.002*** (-869.67)
Ln(FDI)	0.03** (2.42)	0.02** (1.48)	0.02 (1.38)	0.05*** (3.69)	0.05*** (3.32)	0.08*** (6.66)	0.06*** (2.64)	0.05*** (18.81)	0.04*** (13.95)	0.07*** (17.29)	0.07*** (22.93)	0.06*** (22.26)	0.08*** (27.03)	0.07*** (23.47)	0.13*** (67.54)
IRG													-0.10*** (-27.40)		
IRG lag (t-1)		-0.07** (-2.19)				-0.04* (-1.88)				-0.14*** (-28.96)				-0.15*** (-32.02)	
IRG lag (t-2)	-0.10*** (-6.34)			-0.11** (-2.53)				-0.05*** (-17.30)			-0.12*** (-22.89)				
IRG lag (t-3)			-0.03 (-1.13)		-0.17*** (-11.24)		-0.19*** (-11.01)		-0.14*** (-36.05)			-0.18*** (-44.13)			-0.06*** (-22.94)
Constant	-10.96*** (-3.10)	-6.61** (-2.29)	-3.45 (-0.96)	-1.08 (-1.12)	-0.03 (-0.03)	-2.34*** (-2.26)	-1.25 (-1.03)	-2.65*** (-14.26)	-5.69*** (-21.77)	-4.12*** (-15.02)	-4.352*** (-13.79)	-4.27*** (-13.75)	-3.46*** (-14.13)	-4.49*** -18.18)	-3.22*** (-48.23)
No. obs.	188	188	188	253	255	253	255	574	519	441	443	443	440	441	683
No. Countries	36	36	36	52	52	52	52	88	88	88	88	88	88	88	152
Period (4-year or 5-year)	5year	5-year	5-year	5-year	5-year	5-year	5year	4year	4year	5year	5year	5-year	5year	5-year	5year
AR(2)	0.665	0.625	0.579	0.051	0.058	0.048	0.059	0.082	0.596	0.055	0.054	0.082	0.062	0.052	0.053
Hansen	0.700	0.697	0.745	0.888	0.604	0.875	0.913	0.715	0.569	0.459	0.285	0.326	0.520	0.325	0.498

Notes: *denotes statistical significance at the 10%, **at the 5%, ***at the 1% level. T-statistics are in parenthesis. The G3 group is the richest (above US11,906 in 2008); the G2 group being the middle range one (between US$3,855 and US$11,906); and the G1 group being the lowest income range one (between US$975 and US$3,855). See Table 1 for more precise definitions of variables.

Table 3a: The effect of LPS on Economic Growth (GMM Model).

The signs of IRG and IRI are expected to be negative: higher growth rates of GDP per capita are associated with lower inventories to sales ratio over time (as per panel data). The AR (2) and Hansen tests are satisfactory for all regressions shown in these two tables.

Regarding the FE method, the results, as shown in Table 3c, are overall similar to those of the GMM method, although the magnitude and signs of some coefficients of the control variables are not always consistent. However, the magnitude and sign of our variables of immediate interest, IRG and IRI, are very similar to those obtained with GMM. Due to lack of data for the entire 31-year period (used in our regressions) for the variables R&D (RAD) and institutional performance (INS), the Hausman-Taylor (HT) estimation method is applied. This method enables us to estimate the direct impact of technical innovations (as proxied by R&D) and institutions (INS) in the regressions[16]. Unsurprisingly, R&D and INS are significantly related with economic growth and the presence of these variables does not affect much the statistical significance of IRG or IRI in the HT model. This suggests that IRG or IRI works as a significant independent force on economic growth. The IRI or IRG has a negative and large coefficient that is statistically significant in all specifications of the HT regression as shown in Table 3d. Thus, regarding the Hausman-Taylor method, Table 3d shows the results which once more confirm our expectations about the role of IRG, IRI, R&D, institutions, and all other control variables as above. Overall, the results are similar to those with FE and GMM models. Consequently, all technology variables, R&D, investment and inventories to sales ratios contribute in the process of economic growth in a parallel way.

We will now turn to the level variables of GDP per capita and labor productivity as our dependent variable, according to our theoretical growth models discussed in section 3. The GMM results are presented in Table 4a. The control variables are the same as previously. Since we have the dependent variable expressed in level terms, then we also included the lagged dependent of previous year or even (previous two years). The results shown are for either all countries together or for only the three major groups G1, G2, and G3, or for the combinations of

[16]World Development Indicators (WDI) has consistent R&D data (as % of GDP) available from 1999 to 2008 and Worldwide Governance Indicators (WGI) for INS cover the period from 1996 to 2009. Thus we took 10-year average of R&D expenditure and institutional quality to be used in the HT model, which allows us to have consistent and unbiased estimators through the use of instrumental variables technique. In any case, using R&D and INS as invariant to time might be close to reality because these two variables do not change much over time.

Dependent Variable: Real GDP per capita Growth Rate	G3				G1+G2+G3					All countries
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
ln(RGPC_INI)	-1.18*** (-8.61)	-1.10*** (-5.03)	-1.47*** (-11.77)	-1.30*** (-8.88)	-0.34*** (-26.23)	-0.47*** (-14.16)	-0.30*** (-12.11)	-0.27*** (-11.38)	-0.29*** (-17.10)	-0.16*** (-13.71)
ln(GC)	-1.75*** (-2.92)	-2.09*** (-4.45)	-2.26*** (-4.35)	-1.40*** (-3.58)	-3.66*** (-68.69)	-2.66*** (-15.20)	-3.98*** (-32.48)	-4.49*** (-35.02)	-4.11*** (-43.57)	-3.32*** (-78.34)
ln(I)	1.05*** (3.05)	0.92** (2.23)	0.61*** (4.20)	1.42*** (3.43)	2.74*** (66.15)	2.75*** (66.62)	2.99*** (40.33)	3.05*** (44.23)	2.81*** (57.63)	2.95*** (111.88)
POPG	-0.16** (-2.18)	-0.15* (-1.68)	-0.04 (-0.54)	-0.14* (-1.88)	-0.40*** (-37.07)	-0.32*** (-7.15)	-0.44*** (-21.36)	-0.47*** (-28.04)	-0.41*** (-29.30)	-0.40*** (-42.10)
ln(OP)	0.16 (0.67)	0.38 (1.04)	-0.15 (-0.50)	-0.07 (-0.29)	-0.11** (-2.22)	-0.16 (-1.45)	0.18** (2.23)	0.13 (0.92)	0.26*** (3.79)	1.73*** (42.93)
ln(SSE)	2.75*** (9.10)	2.84*** (8.24)	3.25*** (8.00)	3.01*** (10.74)	1.99*** (77.85)	2.18*** (18.75)	1.91*** (41.52)	-2.01*** (38.02)	1.88*** (36.97)	0.20*** (9.94)
INFP	-0.01** (-2.43)	-0.01*** (-3.58)	-0.01** (-2.44)	-0.01*** (-3.25)	-0.006*** (-148.71)	-0.005*** (-183.89)	-0.003*** (-136.81)	-0.003*** (-85.29)	-0.03*** (-298.52)	-0.002*** (-373.49)
Ln(FDI)	0.02 (1.50)	0.01* (1.84)	0.01 (1.09)	0.01 (1.28)	0.06*** (36.78)	0.04*** (16.30)	0.053*** (7.45)	0.07*** (14.55)	0.65*** (19.47)	0.10*** (33.74)
IRI				-0.56* (-1.81)					-0.16** (-2.59)	
IRI_lag (t-1)		-0.68** (-2.28)						-1.90*** (-4.66)		
IRI_lag (t-2)	-0.44*** (-5.19)				-0.04*** (-4.96)		-0.86*** (-5.51)			
IRI_lag (t-3)			-1.19*** (-9.77)			-0.17*** (-11.03)				-1.20*** (-123.39)
Constant	2.30 (1.16)	1.66 (0.67)	7.04*** (3.34)	1.11 (0.48)	-1.28*** (5.25)	-3.60*** (-6.21)	-2.42*** (-7.22)	-1.66*** (-5.75)	-1.96*** (-8.86)	-4.74*** (-35.26)
No. obs.	188	188	188	188	568	514	439	438	437	673
No. Countries	36	36	36	36	88	88	88	88	88	148
Period (4-year or 5-year)	5-year	5-year	5-year	5-year	4-year	4-year	5-year	5-year	5-year	5-year
AR(2)	0.661	0.574	0.949	0.655	0.096	0.581	0.069	0.065	0.079	0.048
Hansen	0.746	0.766	0.791	0.886	0.644	0.144	0.195	0.162	0.262	0.693

Notes: *denotes statistical significance at the 10%, **at the 5%, ***at the 1% level. T-statistics are in parenthesis. See Table 5A for definitions of groups G1, G2, and G3.

Table 3b: The effect of LPS on Economic Growth (GMM Model) cont.

Dependent Variable: Real GDP per-capita Growth Rate	G3		G1+G2		G1+G2+G3		All		G2+G3		G1+G2+G3		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
ln(RGPC_INI)	-4.863*** (1.026)	-4.898*** (1.025)	-6.052*** (1.008)	-6.711*** (1.011)	-7.213*** (0.744)	-7.461*** (0.744)	-6.346*** (0.594)	-6.906*** (0.789)	-7.055*** (0.792)	-7.123*** (0.797)	-6.862*** (0.722)	-6.859*** (0.721)	-6.929*** (0.720)
ln(GC)	-2.391* (1.422)	-2.224 (1.405)	-1.170 (0.888)	-0.777 (0.898)	-1.525** (0.727)	-1.419* (0.727)	-1.752*** (0.59)	-2.440*** (0.844)	-2.089** (0.823)	-2.187*** (0.822)	-2.086*** (0.739)	-1.878** (0.728)	-1.894*** (0.725)
ln(I)	4.150*** (1.198)	4.170*** (1.195)	3.784*** (0.973)	4.524*** (0.956)	5.042*** (0.744)	5.320*** (0.737)	3.428*** (0.539)	4.252*** (0.875)	4.563*** (0.918)	4.448*** (0.892)	4.687*** (0.728)	4.613*** (0.718)	4.629*** (0.694)
POPG	-0.502 (0.305)	-0.540* (0.298)	2.279*** (0.530)	2.171*** (0.547)	0.473 (0.297)	0.582* (0.297)	0.161 (0.185)	0.187 (0.290)	0.150 (0.291)	0.167 (0.290)	0.535* (0.301)	0.540* (0.301)	0.550* (0.300)
ln(OP)	4.506*** (1.110)	4.441*** (1.102)	-0.251 (0.969)	-0.146 (0.976)	-0.055 (0.736)	0.099 (0.732)	1.016* (0.598)	1.429* (0.852)	1.571* (0.847)	1.627* (0.845)	0.079 (0.711)	-0.023 (0.706)	-0.009 (0.701)
ln(SSE)	1.151 (1.068)	1.060 (1.066)	-4.402*** (1.396)	-4.861*** (1.410)	-1.382 (0.937)	-1.599* (0.939)	-2.416*** (0.539)	0.118 (1.044)	-0.143 (1.033)	-0.218 (1.031)	-0.910 (0.951)	-0.999 (0.949)	-1.024 (0.945)
FDI	-0.156 (0.315)	0.012 (0.016)	1.224*** (0.395)	-0.013 (0.031)	0.705** (0.279)	-0.003 (0.018)	0.011 (0.018)	0.021 (0.016)	0.021 (0.016)	0.021 (0.016)	0.013 (0.017)	0.013 (0.017)	0.012 (0.017)
INFP	-0.017** (0.007)	-0.017** (0.007)	-0.003*** (0.0005)	-0.003*** (0.0006)	-0.004*** (0.0005)	-0.004*** (0.0005)	-0.004*** (0.0003)	-0.004*** (0.0007)	-0.005*** (0.0007)	-0.005*** (0.0007)	-0.002*** (0.0004)	-0.002*** (0.0004)	-0.002*** (0.0004)
IRG_lag (t-1)								-0.147*** (0.056)			-0.121** (0.055)		
IRG_lag (t-2)									-0.152*** (0.055)			-0.120** (0.051)	
IRG_lag (t-3)	-0.114* (0.060)	-0.113* (0.060)	-0.118* (0.061)	-0.139** (0.062)	-0.151*** (0.045)	-0.155*** (0.045)	-0.066** (0.033)			-0.154*** (0.055)			-0.139*** (0.049)
Constant	19.823 (14.011)	19.953 (14.000)	48.214*** (7.686)	49.887*** (7.712)	53.349*** (6.841)	52.992*** (6.824)	51.545*** (5.327)	47.551*** (7.585)	47.392*** (7.576)	48.665*** (7.554)	53.783*** (6.924)	54.210*** (6.930)	54.847*** (6.909)
No. obs.	219	219	296	300	515	519	797	327	328	328	441	443	443
No. Countries	36	36	52	52	88	88	152	65	65	65	88	88	88
Periods (4-year or 5-year)	4-year	4-year	4-year	4-year	4-year	4-year	4-year	5-year	5-year	5-year	5-year	5-year	5-year
R-sq.within (R-sq between)	0.442 (0.254)	0.443 (0.269)	0.618 (0.058)	0.602 (0.054)	0.511 (0.007)	0.503 (0.004)	0.454 (0.012)	0.491 (0.060)	0.495 (0.058)	0.495 (0.056)	0.459 (0.005)	0.459 (0.004)	0.463 (0.004)

Note: G1, G2 and G3 stand for LMI (Lower middle-income), UMI (upper middle-income), and HI (High-income) economies respectively. Middle-income economies are those with a GNI per capita of more than $975 but less than $11,906. LMI (Lower middle-income) and UMI (upper middle-income) economies are separated at a GNI per capita of $3,855. HI (High-income) economies are those with a GNI per capita of $11,906 or more.
*denotes statistical significance at the 10%, **at the 5%, ***at the 1% level. Standard errors are in parenthesis. Period dummies are included in all models; however, they are not reported. For models (1), (3), and (5) we used log of FDI for robustness check; in this case we calculated log (FDI+1) to avoid log of zero. .

Table 3c: The effect of LPS on Economic Growth (Fixed Effects Model).

Citation: Sanidas E, Shin W (2017) Lean Production System and Economic Development across the World Today. Int J Econ Manag Sci 6: 480. doi: 10.4172/2162-6359.1000480

Dependent Variable: Real GDP per-capita Growth Rate		**G2+G3**		**G1+G2+G3**		**All**		**G2+G3**		**G1+G2+G3**		**All**	
		(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**	**(7)**	**(8)**	**(9)**	**(10)**	**(11)**	**(12)**
Time-Varying Exogenous Variables	ln(RGPC_INI)	-3.940*** (-6.211)	-5.485*** (-7.846)	-4.730*** (-8.047)	-6.155*** (-9.675)	-4.677*** (-8.539)	-5.865*** (-10.11)	-4.547*** (-7.355)	-4.648*** (-7.456)	-4.658*** (-8.025)	-4.787*** (-8.200)	-4.583*** (-8.329)	-3.963*** (-7.504)
	ln(GC)	-2.876*** (-3.602)	-2.093** (-2.523)	-2.361*** (-3.280)	-1.394* (-1.891)	-3.553*** (-5.299)	-2.667*** (-3.900)	-2.361*** (-3.101)	-2.433*** (-3.193)	-1.771** (-2.474)	-1.795** (-2.518)	-3.274*** (-4.802)	-3.099*** (-4.572)
	POPG	0.174 (0.650)	0.138 (0.495)	0.260 (0.981)	0.300 (1.087)	0.196 (0.801)	0.186 (0.741)	0.046 (0.174)	0.052 (0.197)	0.263 (0.966)	0.261 (0.961)	0.096 (0.375)	0.042 (0.163)
	ln(OP)	-0.028 (-0.045)	-0.063 (-0.089)	-0.681 (-1.119)	-0.719 (-1.079)	-0.305 (-0.502)	-0.442 (-0.684)	0.188 (0.298)	0.230 (0.366)	-0.567 (-0.921)	-0.541 (-0.882)	-0.356 (-0.570)	-0.539 (-0.874)
	ln(SSE)	0.533 (0.521)	-0.257 (-0.253)	-0.992 (-1.101)	-2.037** (-2.253)	-0.856 (-1.157)	-2.034*** (-2.665)	-0.621 (-0.639)	-0.656 (-0.678)	-1.481 (-1.643)	-1.541* (-1.713)	-1.217 (-1.593)	-1.067 (-1.414)
	INFP	-0.006*** (-7.852)	-0.005*** (-7.267)	-0.005*** (-9.565)	-0.005*** (-9.073)	-0.004*** (-10.06)	-0.004*** (-10.53)	-0.005*** (-7.551)	-0.005*** (-7.539)	-0.002*** (-5.811)	-0.002*** (-5.757)	-0.002*** (-7.246)	-0.002*** (-6.815)
Time-Varying Endogenous Variables	ln(I)	4.244*** (4.855)	5.181*** (5.399)	5.411*** (7.008)	5.909*** (7.305)	5.600*** (8.140)	5.747*** (8.092)	4.286*** (4.872)	4.265*** (5.024)	5.217*** (6.544)	5.311*** (6.936)	5.414*** (7.560)	5.583*** (7.971)
	FDI	0.012 (0.768)	0.016 (0.989)	-0.007 (-0.468)	-0.014 (-0.899)	-0.003 (-0.179)	-0.008 (-0.470)	0.013 (1.057)	0.013 (1.027)	0.001 (0.095)	0.001 (0.090)	0.012 (0.686)	0.012 (0.715)
	IRG_lag (t-2)	-0.075* (-1.619)		-0.093** (-2.099)		-0.089** (-2.341)		-0.105** (-2.047)		-0.110** (-2.139)		-0.093** (-2.083)	
	IRG_lag (t-3)		-0.164*** (-3.362)		-0.154*** (-3.409)		-0.122*** (-3.110)		-0.114** (-2.223)		-0.136*** (-2.742)		-0.099** (-2.315)
Time-Invariant Exogenous Variables	RAD	1.532** (2.407)	2.011** (2.563)	1.713** (2.178)	2.127** (2.273)	1.541* (1.824)	1.895* (1.933)	1.799*** (2.619)	1.848*** (2.653)	1.709** (2.197)	1.761** (2.224)	1.573* (1.872)	1.295* (1.735)
	INS	3.496*** (3.592)	4.874*** (4.240)	5.957*** (5.392)	7.698*** (6.095)	6.688*** (5.991)	8.341*** (6.673)	4.077*** (4.052)	4.166*** (4.094)	5.917*** (5.410)	6.045*** (5.464)	6.559*** (5.844)	5.784*** (5.574)
Constant		22.83*** (3.407)	31.76*** (4.509)	30.64*** (5.046)	40.04*** (6.326)	30.35*** (5.660)	40.12*** (7.191)	28.87*** (4.542)	29.84*** (4.722)	29.46*** (4.914)	30.32*** (5.084)	30.09*** (5.519)	25.13*** (4.702)
No. obs.		409	369	534	482	655	589	315	315	411	411	504	506
No. Countries		62	62	81	81	106	105	62	62	81	81	106	105
Periods (4-year or 5-year)		4-year	4-year	4-year	4-year	4-year	4-year	5-year	5-year	5-year	5-year	5-year	5-year
Wald Chi-sq.($\mathcal{K}_1$-$\mathcal{G}_2$)		181.1*** (12)	228.8*** (12)	302.2*** (12)	383.8*** (12)	360.3*** (12)	460.1*** (12)	217.9*** (12)	219.9*** (12)	244.9*** (12)	250.7*** (12)	285.2*** (12)	285.2*** (12)

Note: G1, G2 and G3 stand for LMI (Lower middle-income), UMI (upper middle-income), and HI (High-income) economies respectively. Middle-income economies are those with a GNI per capita of more than $975 but less than $11,906. LMI (Lower middle-income) and UMI (upper middle-income) economies are separated at a GNI per capita of $3,855. HI (High-income) economies are those with a GNI per capita of $11,906 or more.
*denotes statistical significance at the 10%, **at the 5%, ***at the 1% level. Z-statistics are in parenthesis. Period dummies as time-varying exogenous variables are included in all models; however, they are not reported. The order condition for instrument is satisfied in all models ($\mathcal{K}_1$ denotes exogenous variables, and $\mathcal{G}_2$ denotes endogenous variables).

Table 3d: The effect of LPS on Economic Growth (Hausman-Taylor Model).

the sub groups such as G1+G2 or G2+G3 (for some other sub groups, we find similar results but not reported here for space limitations). The results are robust again showing the right signs as expected and with significant coefficients. In particular the variable inventory to GDP ratio IRG[17] is again significant and has a negative sign as in the case of GDP per capita growth rates being the dependent variable. The fixed effects results are shown in Table 4b with similar conclusions as for the GMM results.

These results are overall robust since we used many countries, several samples[18] according to stages of economic development, 4-year or 5-year averages to smooth out business cycles; three different econometric methods for panel data; several control variables at the same time; and various lags of the key variables IRG and IRI. The magnitude of coefficients is reasonable and as expected. For example, both investment in new capital of equipment and machines (lnI) and inventories ratios (IRG and IRI) are important in contributing to economic growth; the elasticity of new capital is larger than that of the LPS proxies. Also, R&D as a proxy of technical innovations and INS as a proxy for institutional quality are, in parallel with other variables, contributing to economic growth. Furthermore, comparing the results for developed as against less developed countries, the GMM results in particular show significant differences that agree with our expectations regarding the role of each variable in the two groups. Thus, for both the investment to GDP and the inventories to sales ratios, the coefficients are larger for the less developed nations in most models; the same applies for some other coefficients such as investment; and so on. In particular FDI and sometimes trade openness are significant, thus confirming the globalization issue mentioned earlier. Overall, our empirical evidence supports the theoretical background we presented in previous sections which suggested that inventories in modern production systems have the tendency to decline over the long run and hence they contribute to economic growth in an endogenous way.

[17] We also obtained some significant results with the other proxy of IRI.

[18] In an earlier version of our paper we used 69 countries (available upon request) which are a somehow arbitrary selection of developed and developing countries. The results were also similar to those presented here with our extended sampling process.

Dependent Variable	GDP per Capita								Labor Productivity							
	G2+G3		G1+G2+G3			All Countries			G2+G3		G1+G2+G3			All Countries		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)
lnRGPPPC_ lag(period-1)	1.19*** (0.285)	0.90*** (0.225)	0.71*** (0.127)	0.60*** (0.103)	0.51*** (0.088)	0.47*** (0.134)	0.47*** (0.122)	0.53*** (0.152)								
lnRGPPPC_ lag(period-2)	-0.18 (0.158)	-0.07 (0.128)	-0.09 (0.093)	0.03 (0.074)	0.17*** (0.061)	-0.01 (0.111)	0.04 (0.086)	0.07 (0.124)								
lnLP									0.67** (0.271)	0.09 (0.205)	-0.16 (0.226)	-0.12 (0.180)	-0.10 (0.141)	0.44*** (0.108)	0.41*** (0.123)	0.29** (0.135)
ln(GC)	-0.37 (0.599)	-0.35 (0.543)	-1.44*** (0.483)	-1.01** (0.484)	-0.53 (0.478)	-1.31** (0.611)	-0.89* (0.538)	-1.37** (0.688)	0.03 (0.314)	0.63 (1.091)	0.59 (1.216)	0.34 (0.964)	0.73 (0.593)	-1.66** (0.703)	-1.63*** (0.620)	-0.90 (0.761)
ln(I)	1.95*** (0.626)	1.59*** (0.528)	1.06*** (0.278)	0.99*** (0.283)	1.41*** (0.246)	1.00** (0.402)	1.22*** (0.356)	1.48*** (0.553)	0.10 (0.372)	0.50 (0.519)	0.93*** (0.269)	0.85** (0.344)	0.61* (0.345)	0.68*** (0.223)	1.18*** (0.360)	1.32*** (0.422)
POPG	-0.01 (0.062)	0.04 (0.058)	0.03 (0.087)	0.00 (0.075)	-0.00 (0.067)	-0.03 (0.047)	-0.01 (0.043)	-0.03 (0.048)	0.33* (0.171)	0.24** (0.111)	0.31** (0.134)	0.26** (0.118)	0.24** (0.102)	-0.09** (0.040)	-0.08 (0.050)	-0.05 (0.043)
ln(OP)	-0.03 (0.390)	-0.38 (0.373)	-0.83** (0.351)	-1.08*** (0.266)	-1.00*** (0.227)	-1.40** (0.625)	-1.55*** (0.577)	-1.00 (0.723)	1.71** (0.669)	-0.33 (0.253)	-0.35 (0.224)	-0.32 (0.216)	-0.31* (0.179)	-0.00 (0.173)	-0.01 (0.177)	-0.03 (0.174)
ln(SSE)	0.29 (0.475)	0.84** (0.407)	1.16*** (0.325)	1.09*** (0.246)	0.81*** (0.240)	1.08*** (0.217)	0.99*** (0.199)	0.79*** (0.235)	0.44 (0.696)	1.90*** (0.406)	2.31*** (0.348)	2.26*** (0.345)	2.04*** (0.318)	0.76*** (0.124)	0.77*** (0.152)	0.85*** (0.151)
INFP	0.0001 (0.0004)	0.0002 (0.0003)	0.0001 (0.0001)	0.0001 (0.0001)	0.00001 (0.0001)	-0.0001 (0.0001)	-0.0002 (0.0002)	-0.0001 (0.0001)	-0.00*** (0.001)	-0.00 (0.001)	0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)	-0.0001 (0.0001)	0.0001 (0.0001)	0.0001 (0.0001)
Ln(FDI)	-0.01 (0.123)	0.14 (0.106)	0.35*** (0.112)	0.40*** (0.115)	0.28*** (0.108)	0.06 (0.193)	0.16 (0.173)	0.07 (0.215)	-0.05 (0.140)	0.29* (0.149)	0.05 (0.080)	0.11 (0.093)	0.17 (0.110)	0.27** (0.132)	0.10 (0.142)	-0.09 (0.180)
IRG lag (t-1)			-0.10*** (0.028)			-0.06* (0.035)					-0.06*** (0.016)			-0.03*** (0.011)		
IRG lag (t-2)	-0.13*** (0.025)			-0.09*** (0.018)			-0.08*** (0.026)		-0.04* (0.020)			-0.04*** (0.012)			-0.04*** (0.015)	
IRG lag (t-3)		-0.10*** (0.027)			-0.09*** (0.021)			-0.07** (0.034)		-0.02** (0.013)			-0.03*** (0.010)			-0.05*** (0.015)
Constant	-5.79** (2.451)	-4.33** (2.171)	2.26 (1.756)	2.58* (1.452)	0.66 (1.241)	6.74*** (2.061)	5.42*** (1.771)	3.76* (2.267)	-6.27* (3.496)	-1.69 (2.329)	-2.15 (1.990)	-1.57 (1.662)	-1.33 (1.316)	4.41*** (1.227)	3.22** (1.326)	1.90 (1.689)
No. obs.	268	268	362	364	364	562	562	566	343	342	460	460	460	697	698	697
No. Countries	65	65	88	88	88	151	151	151	61	61	83	83	83	137	135	135
Period (4-year or 5-year)	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	4-year	4-year	4-year	4-year	4-year	4-year	4-year	4-year
AR(2)	0.442	0.364	0.175	0.186	0.230	0.374	0.370	0.094	0.114	0.181	0.743	0.810	0.638	0.067	0.330	0.918
Hansen	0.380	0.907	0.341	0.407	0.431	0.348	0.218	0.659	0.547	0.749	0.867	0.516	0.316	0.116	0.284	0.189

Notes: see previous Tables. Standard errors are in parenthesis.

Table 4a: The effect of LPS on Economic Development (GDP per Capita, Labor Productivity, and Total Factor Productivity) in Levels (GMM Model)

Conclusion

The aim of this paper is threefold. First, it is to show in the context of a standard macro-economic growth model that the long term trend of inventories ratio (either over GDP or investment) plays a significant and positive role. Second, this positive role exists because the long term of the inventories ratio has been declining. And third, we highlight the possible link between this declining ratio (or smaller changes in inventories) is between the introduction of modern production systems (such as lean production, etc.).

As far as we know this is the first rigorous econometric attempt to achieve this threefold aim. We used panel data for at least 88 countries all over the world for the period 1978 to 2008 by grouping the dependent variable of GDP per capita growth and several control variables plus the inventories ratio into four or five years periods in order to eliminate the influence of business cycles. To carry out the empirical analysis we used panel data techniques such as GMM which takes into account the issue of endogeneity between growth rates and inventories ratios.

We reviewed the new production systems (lean or flexible, just-in-time, etc.) in the light of some pioneering theoretical articles which clearly show that the declining trend of the inventories ratios is a natural consequence of these systems. As recent theoretical and empirical studies show, the behavior of inventories ratios changed since the 1980s. This coincided with the gradual introduction of the new production systems or possibly globalization (captured by FDIs and global production networks). In order to see how spread out in the world these systems have been we conducted a literature review that brings evidence of a considerable penetration of these modern production systems in the countries we examined.

Our results show that controlling for various explanatory variables, economic growth of the countries included in our study is significantly and positively influenced by the declining trend of the inventories ratio (thus the coefficient of this ratio is negative) in the context of panel data analysis. These results are robust since we have separated our sample into sub-samples of groups of countries and since we used several panel data

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Dependent Variable	GDP per Capita						Labor Productivity						TFP	
	G2+G3			All Countries			G2+G3			All Countries			OECD Countries	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
lnRGPPPC_ lag(period-1)	0.70*** (0.060)	0.68*** (0.058)	0.68*** (0.058)	0.84*** (0.048)	0.83*** (0.048)	0.83*** (0.048)								
lnRGPPPC_ lag(period-2)	-0.31*** (0.063)	-0.28*** (0.062)	-0.26*** (0.062)	-0.34*** (0.051)	-0.32*** (0.051)	-0.30*** (0.051)								
lnLP lag(period-1) or TFP_initial year							0.41*** (0.057)	0.39*** (0.056)	0.38*** (0.056)	0.53*** (0.040)	0.54*** (0.040)	0.55*** (0.039)	0.9385*** (0.01473)	0.9375*** (0.01474)
ln(GC)	0.19* (0.103)	0.18** (0.088)	0.14 (0.088)	-0.03 (0.062)	-0.01 (0.060)	-0.00 (0.060)	0.18 (0.118)	0.20* (0.105)	0.21* (0.105)	-0.07 (0.075)	-0.07 (0.073)	-0.06 (0.073)		
ln(I)	0.64*** (0.096)	0.70*** (0.094)	0.70*** (0.094)	0.16*** (0.057)	0.18*** (0.056)	0.19*** (0.055)	0.53*** (0.114)	0.58*** (0.113)	0.56*** (0.112)	0.17*** (0.066)	0.18*** (0.065)	0.21*** (0.064)		
ln(OP)	-0.20** (0.091)	-0.19** (0.088)	-0.18** (0.088)	-0.08 (0.062)	-0.10* (0.062)	-0.10* (0.062)	-0.11 (0.124)	-0.09 (0.121)	-0.09 (0.121)	0.004 (0.077)	-0.003 (0.076)	-0.01 (0.076)		
ln(SSE)	-0.04 (0.099)	0.00 (0.095)	-0.01 (0.095)	-0.10 (0.059)	-0.08 (0.059)	-0.06 (0.057)	-0.12 (0.125)	-0.10 (0.121)	-0.13 (0.119)	-0.16** (0.070)	-0.16** (0.070)	-0.14** (0.068)		
INFP	-0.00007 (0.00007)	-0.00004 (0.00005)	-0.00006 (0.00007)	-0.00007** (0.00003)	-0.00007** (0.00003)	-0.00004 (0.00003)	-0.00006 (0.00007)	-0.00005 (0.00007)	-0.00004 (0.00007)	-0.0001*** (0.00003)	-0.0001*** (0.00003)	-0.0001*** (0.00002)		
Ln(FDI)	0.04 (0.031)	0.04 (0.030)	0.03 (0.030)	0.06** (0.025)	0.06** (0.024)	0.06** (0.024)	0.08* (0.039)	0.08** (0.038)	0.07* (0.039)	0.08*** (0.030)	0.08*** (0.029)	0.08*** (0.029)		
IRG lag (t-1)	-0.03*** (0.006)			-0.01 (0.005)			-0.03*** (0.007)			-0.01 (0.005)				
IRG lag (t-2)		-0.04*** (0.006)			-0.01** (0.004)			-0.03*** (0.007)			-0.01* (0.005)		-0.0114** (0.0031)	
IRG lag (t-3)			-0.04*** (0.006)			-0.01** (0.004)			-0.03*** (0.007)			-0.01* (0.005)		-0.0101*** (0.0037)
Constant	4.37*** (0.829)	3.80*** (0.812)	3.82*** (0.811)	3.89*** (0.461)	3.83*** (0.460)	3.49*** (0.441)	5.12*** (1.068)	4.94*** (1.039)	5.23*** (1.029)	4.15*** (0.561)	4.06*** (0.554)	3.81*** (0.539)	0.3008*** (0.0677)	0.3047*** (0.0678)
No. obs.	267	268	268	562	562	566	250	251	251	513	514	517	101	101
No. Countries	65	65	65	151	151	151	61	61	61	136	136	135	22	22
Period (4-year or 5-year)	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year	5-year
R-sq.within (R-sq between)	0.904 (0.863)	0.911 (0.808)	0.911 (0.880)	0.799 (0.973)	0.804 (0.969)	0.803 (0.978)	0.865 (0.846)	0.871 (0.820)	0.870 (0.810)	0.744 (0.948)	0.752 (0.949)	0.752 (0.960)	0.982 (0.912)	0.982 (0.917)

Notes: *denotes statistical significance at the 10%, **at the 5%, ***at the 1% level. Standard errors are in parenthesis. The G3 group is the richest (above US11,906 in 2008); the G2 group being the middle range one (between US$3,855 and US$11,906); and the G1 group being the lowest income range one (between US$975 and US$3,855).

Table 4b: The effect of LPS on Economic Development (GDP per Capita, Labor Productivity) in Levels (Fixed Effects).

techniques (FE, GMM, and HT). Also we used several samples ranging from 69, mostly 88, and sometimes up to 152 countries. Consistently, our results indicate that countries which continually reduce inventories ratios have higher rates of economic growth even, after controlling for initial development stage, physical and human capital, population growth, government consumption, inflation rate, trade openness, FDI, and furthermore, institutional quality and technology levels. The magnitude and signs of all coefficients are consistent and as expected according to standard practice in empirical economics.

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