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Autonomous Demand and the Investment Share

Daniele Girardi¹ and Riccardo Pariboni²

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Abstract – This paper looks at the effect of demand shocks on the investment share of the economy. Using panel data on 20 OECD countries, we show that the rate of growth of autonomous demand (exports, public spending and housing investment) is positively correlated with subsequent values of the share of business investment in GDP. By means of an instrumental-variables strategy, we confirm a positive effect of demand dynamics on the business investment share. We instrument autonomous demand with US demand for imports interacted with exposure to trade with the US, openness to trade of a country's main export destinations, and military spending. A permanent 1% increase in autonomous demand growth raises the investment share by 1.5 to 1.9 percentage points of GDP in our preferred panel IV specification. Our results provide empirical support for the view that the influence of aggregate demand on capital accumulation can be a major source of hysteresis. Our results are inconsistent with the canonical New Keynesian 3-equations model, the Neo-Kaleckian model with flexible equilibrium utilization and Classical-Marxian growth models. A positive influence of autonomous demand on the investment share is instead compatible with demand-led models in which capacity adjusts to demand in the long-run.

Keywords: Hysteresis, Investment, Demand-led Growth, Capacity Adjustment, Supermultiplier.

JEL Classification: C26; E11; E12; E22; O41

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1 - Introduction and motivation

What determines the share of national product that is devoted to private productive investment? Does it depend solely on structural supply-side factors and preferences (“thriftiness”), as implied by neoclassical macroeconomics? Or can it be influenced by aggregate demand trends, fiscal policy, and export dynamics? The question is highly relevant, given that the investment share is positively associated with long-run economic potential both theoretically and empirically. It also relates to the ongoing debate on hysteresis:³ recent contributions have pointed to the impact of demand on capital accumulation as a major potential source of hysteresis (e.g. Ball, 2014; Reifschneider et al., 2015; Fatás and Summer, 2016). Indeed, a positive effect of aggregate demand dynamics on the investment share would not be compatible with theoretical models in which potential output is independent of aggregate demand.

This paper tackles this question empirically: we estimate the effect of autonomous demand on the share of business investment in GDP.

Our empirical analysis uses a quarterly and a yearly panel of 20 advanced economies for the 1960-2016 period. We define autonomous demand as the sum of exports, public spending and housing investment. This definition reflects a simple Keynesian model, in which consumption and business investment are induced (determined by current and expected income), while exports and government spending are the components of aggregate demand that can potentially move independently of income. We include also housing investment in our definition of autonomous demand, because it is partly determined by demographic and financial factors. Note that our definition of autonomous demand does not imply statistical exogeneity: exports, public spending and housing expenditure are certainly influenced by domestic macroeconomic conditions. In fact, we take endogeneity issues seriously, and propose an instrumental-variable approach to isolate exogenous variation in autonomous demand.

First, we use dynamic panel models to show that changes in autonomous demand growth tend to be followed by changes of the same sign in the business investment share of GDP. This result is robust to controlling for lags of the investment share, two-way fixed effects, the interest rate and the profit share. We find, however, evidence of endogeneity of some autonomous components of demand.

We tackle endogeneity by proposing a panel instrumental-variables approach to estimate the effect of autonomous demand. We propose three external instruments for autonomous demand in a country i :

³ By ‘hysteresis’ we mean the idea that “changes in aggregate demand may have an appreciable, persistent effect on aggregate supply—that is, on potential output” (Yellen, 2016, p. 2).

- US aggregate demand for imports (excluding imports from country i) weighted by i 's exposure to trade with the US;
- weighted-average openness to trade of the five main export destinations of country i ;
- military expenditure.

Our preferred estimates use only variation in autonomous demand that is driven by these three instrumental variables. We also show that our results are robust to using semi-parametric local projections (Jordà, 2005) instead of dynamic panel models. According to our preferred IV specifications, a 1% permanent increase in autonomous demand growth increases the business investment share by 1.5 to 1.9 percentage points of GDP in the long-run.

We then assess the compatibility of our findings with alternative macroeconomic models. Pointing to an effect of aggregate demand on the evolution of productive capacity, our results are at odds with models in which potential output is fully determined by supply side factors. For example, in the canonical Neo-Keynesian 3-equations model, increases in autonomous demand are associated with a reduction of the equilibrium investment share. The same can be said of models in the Classical-Marxian tradition (Duménil and Lévy, 1999), in which long-run outcomes are also supply-determined.

Demand-led growth models are natural candidates to explain our findings. However, this is not true for all such models. Neo-Kaleckian models that rely on flexible equilibrium capacity utilization (Amadeo, 1986; Hein et al., 2012), in fact, are not able to explain our results. The positive influence of autonomous demand on the investment share is instead compatible with autonomous demand-led growth models in which capacity adjusts to demand in the long-run. In Appendix B, we provide a formal stylized model of this class, drawing on the 'Supermultiplier' literature (Freitas and Serrano, 2015), showing that in this framework a higher growth rate of autonomous demand implies a higher investment share.

Besides contributing to a large literature on the determinants of business investment,⁴ our findings are informative for the debate on hysteresis and for models of demand-led growth. To the best of our knowledge, this is the first paper to estimate the impact of autonomous demand shocks on the share of business investment in GDP.⁵ Moreover, we introduce novel instrumental variables for exports, which we think could be used fruitfully in future research on the impact of autonomous demand and exports on various outcome variables.

⁴ See for example the surveys of Chirinko (1993) and Caballero (1999).

⁵A related exercise is performed in Blomström et al. (1996), which investigates the causal relationship between (per capita) GDP growth and the fixed investment share in GDP, concluding that "growth induces subsequent capital formation more than capital formation induces subsequent growth" (Blomström et al., 1996, pp. 275-276). In Girardi and Pariboni (2016) we present some preliminary results on the relationship between autonomous demand and the investment share, within a more general empirical analysis on the role of autonomous demand as a driver of growth in the US.

2 - Identification Issues and Research Design

Estimating the causal effect of autonomous demand growth on the business investment share is challenging, because of the presence of various potential confounders. Changes in the autonomous components of demand are partly endogenous to macroeconomic conditions that affect also business investment and GDP (the numerator and the denominator of our outcome of interest).⁶ Each autonomous component of demand – public spending, exports and housing investment – is indeed likely to react to fluctuations in aggregate business investment and GDP.

We can identify two broad potential sources of endogeneity for our analysis. First, changes in business investment may affect autonomous demand directly and through their effects on GDP growth, generating reverse-causality bias. Second, unobserved shocks to economic activity (due for example to supply-side factors or global macroeconomic factors) could drive both changes in business investment and in the autonomous components of demand, creating a problem of omitted-variable bias.

Our identification strategy is based on the use of panel data techniques and instrumental variables. First, we estimate a dynamic panel model on quarterly data, controlling for a full set of country and time fixed effects, to assess whether changes in autonomous demand tend to predict ('Granger-cause') subsequent changes in the business investment share, and/or vice-versa. This first analysis is useful in exploring possible lead-lag relations between the two variables. It effectively controls for country-specific time-invariant factors and time-varying common shocks, while accounting for persistence in the outcome variable. We also control for the real interest rate and the profit share. However, our panel Granger-causality analysis may still suffer from endogeneity bias related to country-specific time-varying unobserved factors influencing both the treatment and the outcome.

We address these concerns through an instrumental-variables approach. We propose three external instruments for autonomous demand in a country i : US aggregate demand for imports (excluding imports from country i) interacted with country i 's exposure to trade with the US; weighted-average openness to trade of the five main export destinations of country i ; military expenditure. We define and discuss in detail each of these instruments in Section 5. We argue that using only changes in autonomous demand that are driven by these three factors is likely to largely remove endogeneity-bias, producing credible estimates of the causal effect of autonomous demand.

To make sure that our estimates of the effect of autonomous demand on the investment share are not driven by the parametric model imposed by our dynamic panel specification, we also

⁶ Girardi and Pariboni (2015, p. 27 and 2016, pp. 13-14) find that autonomous demand does not appear fully exogenous using US time-series data and discuss at length the potential sources of endogeneity affecting each autonomous component of demand.

present estimates using a semi-parametric local projections (LPs) specification (Jordà 2005). LPs allow to estimate the effect of the treatment at different time-horizons, without assuming any underlying parametric model for the dynamics of the outcome variable. Results from LP estimates confirm that changes in autonomous demand growth have a significant and economically relevant positive effect on the business investment share.

3 - Data and descriptive evidence

Data - We build both a quarterly and a yearly panel including 20 OECD countries for the 1960-2016 period.⁷ The yearly panel will be used in the instrumental-variables estimations, given that the external instruments we will use are not available at a quarterly frequency. Because of data availability, the yearly IV estimations will focus on the 1970-2015 period. Our outcome of interest is the ratio of private non-residential investment to GDP (hereafter, business investment share, or simply investment share). The main regressor of interest is the rate of growth of autonomous demand. We define autonomous demand as the sum of exports, general government final consumption, general government gross fixed capital formation and housing investment. Our dataset also includes, as control variables, the real interest rate and the profit share. The former is the rate of interest on long-term government bonds, corrected for inflation. The latter is the share of gross operating surplus and mixed income, adjusted for the imputed compensation of self-employed, in GDP.

Descriptive statistics are reported in Table 1. All variables are taken in real terms. Quarterly series are all seasonally adjusted. See Appendix A for details on the definitions and sources of all variables.⁸

Descriptive evidence - We start by providing descriptive visual evidence on our relation of interest, using the quarterly panel dataset. The left panel of Figure 1 plots the year-on-year growth rate of autonomous demand (on the horizontal axis) versus the subsequent 1-year ahead change in the business investment share.⁹ Given the large number of observations ($n = 3,287$), we plot local averages instead of single observations for ease of visualization.¹⁰ This means that each point

⁷ The countries are: Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Japan, Korea, Netherlands, New Zealand, Norway, Spain, Sweden, United Kingdom and United States. Our sample includes all the countries for which yearly and quarterly business investment data are available (from the OECD Economic Outlook n. 101 or from previous editions).

⁸ As described in detail in Appendix A, our main source is the OECD Economic Outlook n. 101, but we also used other auxiliary sources for some variables that are not available in the OECD EO.

⁹ The year-on-year growth rate is the % change over the same quarter of the previous year. The 1-year ahead change is the % change between t and $t+4$.

¹⁰ We used the `binscatter` package in STATA to compute and plot local averages.

in the graph represents the average of all observations around that point (this will apply also to Figures 2 to 4). We fit a quadratic regression line to accommodate possible non-linearities.

Figure 1(a) clearly suggests that a higher growth rate of autonomous demand tends to be correlated with a higher subsequent change in the business investment share. The relation seems broadly linear.

The right panel of Figure 1 investigates whether changes in the investment share are correlated with subsequent values of autonomous demand growth. An association between changes in the investment share and subsequent autonomous demand growth would suggest the possible presence of reverse-causality. The association, however, seems to be quite weak. The quadratic regression line seems to point to a U-shaped relation, with no clear positive or negative association between the two variables. In other words, larger changes in the investment share do not seem to predict higher subsequent autonomous demand growth.

The simple descriptive evidence provided by Figure 1 is clearly consistent with a positive impact of autonomous demand growth on the investment share. However, while this simple exercise does not suggest pervasive reverse-causality, obviously it does not prove its absence, and – most importantly – it does not rule out other sources of endogeneity.

The aim of the next two sections is to assess whether the positive relation between autonomous demand and the investment share depicted in Figure 1a is spurious or reflects a genuine causal effect.

4 – Dynamic panel Granger-causality tests

To investigate more formally whether changes in autonomous demand tend to be followed by same-sign changes in the business investment share (as suggested by Figure 1), we perform Granger-causality tests, using a dynamic panel specification on our quarterly dataset.

The regressions we estimate in this Section have the following generic form:

$$I/Y_{i,t} = \alpha_i + \delta_t + \sum_{j=1}^p \beta_j \Delta z_{i,t-j} + \sum_{j=1}^p \gamma_j \Delta(I/Y)_{i,t-j} + \varepsilon_{i,t} \quad (1)$$

where $I/Y_{i,t}$ is business investment as a % of GDP in country i at time t and z is the natural log of autonomous demand. α_i are country fixed-effects and δ_t are (year-quarter) time effects.¹¹ Testing for Granger-causality implies testing the joint hypothesis that $\beta_j = 0$ for all j (Granger 1980).¹²

This specification assumes that I/Y and Δz are stationary variables. This assumption is supported by the panel unit-root tests reported in

Table 2. Both the Im, Peasaran and Shin (2003) and the Levin, Lin and Chu (2002) tests comfortably reject the null of non-stationarity for both variables.

4.1 - Baseline results from dynamic panel models

Table 3 displays results from the estimation of various versions of equation (1). Columns 1 and 2 present results from a pooled OLS estimator (which assumes $\alpha_i = \delta_t = 0$); columns 3 and 4 a within-countries model (that allows for country fixed effects but not time fixed-effects); and columns 5 and 6 a two-way fixed effects model that includes a full set of country and time (year-quarter) dummies. Our preferred specifications include 4 lags (columns 1, 3 and 5), since we find all subsequent lags to be near zero and statistically insignificant. However, for each model, we report results also using 8 lags (columns 2, 4 and 6) for robustness. To account for serial correlation both within countries and within time periods, we report two-way clustered standard errors (Cameron et al., 2011).

Results confirm the indications of Figure 1: lagged values of autonomous demand growth have a positive and significant effect on the business investment share in all specifications. The null-hypothesis that autonomous demand growth does not Granger-cause the investment share is rejected at the 1% significance level in all specifications.

We calculate the long-run effect of autonomous demand implied by our dynamic panel model according to the formula $(\sum_{j=1}^p \beta_j)/(1 - \sum_{j=1}^p \gamma_j)$. In our context, the long-run effect can be interpreted as the change in the equilibrium value of the business investment share caused by a

¹¹ As well-known, the inclusion of both country fixed effects and autoregressive dynamics may generate the so-called ‘Nickell bias’ (Nickell 1981). This bias is however of order $1/T$ and should thus be completely negligible in our large- T panel (we have an average of 171 quarterly observations for each country, with a minimum of 51 and a maximum of 227). Indeed, Judson and Owen (1999) provide evidence from Monte Carlo simulations, suggesting that when estimating dynamic panel models on macroeconomic datasets, the fixed-effects model is superior to the alternatives as long as $T \geq 30$. Nickell bias may be an issue in our yearly dataset, where we have a smaller T , and therefore we will present results both including and excluding country fixed effects.

¹² A Granger causality test is useful in identifying lead-and-lag relationships between time-series. The variable X causes the variable Y , in the sense of Granger, if past values of X contain useful information to predict the present value of Y . Formally, X Granger-causes Y if $E(y_t | y_{t-1}, y_{t-2}, \dots, x_{t-1}, x_{t-2}, \dots) \neq E(y_t | y_{t-1}, y_{t-2}, \dots)$.

permanent 1% increase in the growth rate of autonomous demand. We find a long-run effect between 1.4 and 2.2 percentage points of GDP in the specifications controlling for fixed-effects.

In Table 4 we use the same dynamic panel models to assess whether past values of the business investment share help predict autonomous demand growth – that is, whether the investment share Granger-causes autonomous demand. While the pooled model (that does not control for fixed-effects) confirms the visual evidence of Figure 1(b) of a weak non-significant relation (column 1), in this case the inclusion of fixed-effects changes the picture. The fixed-effects estimates are indeed indicative of some predictive power of the investment share over future values of autonomous demand growth: the null hypothesis of no-Granger causality is rejected at a 5% significance level in all specifications including fixed effects (columns 3 to 6).

4.2 - Robustness of the dynamic panel analysis

In Table 6, we test the robustness of our results to the inclusion of control variables, namely the real interest rate and the profit share. We estimate an augmented version of equation (1), which includes contemporaneous and lagged values of the real interest rate and the profit share. This exercise must be interpreted with caution: it implicitly assumes that the real interest rate and the profit share are exogenously determined. In fact, both variables are in all likelihood correlated with the error term through the Central Bank's reaction function, the negative impact of the unemployment rate on real wages, and the potential effects of changes in investment on the share of capital.¹³ The endogeneity of the two control variables is likely to bias also the coefficients of the treatment of interest (Frölich, 2008, pp. 216-220), which is why we do not include these controls in our baseline Granger-causality specifications. Still, we find it useful to check whether the inclusion of these two potential determinants of business investment alters our results in any meaningful way.

As shown in Table 6, results are not qualitatively altered by the inclusion of these two (endogenous) controls. Coefficients on lagged values of autonomous demand growth remain positive, although less precisely estimated in the specification with quarterly dummies, and the implied long-run effect is positive and of similar magnitude. The null of no-Granger causality is rejected at least at the 10% significance level in all specifications. The implied long-term effects of the interest rate and the profit share are statistically significant and have the expected sign (negative for the interest rate and positive for the profit share), although they can hardly be given a causal interpretation, due to the endogeneity problems just discussed.

4.3 – Disaggregated regressions

¹³ See for example Tavani and Zamparelli (2017), who discuss at length the influence of government consumption on the wage share.

It is important to assess whether the predictive power of autonomous demand growth on the investment share is driven by some single component of autonomous demand, or it is a property of autonomous demand as an aggregate. We estimate a battery of Granger-causality tests using the dynamic-panel model described by equation (1), between each component of autonomous demand and the business investment share. For each component, we also estimate reverse-Granger causality, in order to have a measure of endogeneity.

Results of these ‘disaggregated’ regressions are reported in Table 5. In the interest of facilitating comparison, the first row reports the effect of aggregate autonomous demand implied by our baseline Granger-causality specification. The estimated effects of all autonomous demand components are positive and of similar magnitude in our preferred two-way fixed-effects specification. However, they are imprecisely estimated: only for housing investment we are able to reject the null of no Granger-causality at conventional levels of significance. Overall, these results appear to suggest that the effect of autonomous demand on the investment share is not driven by one single component but is a property of autonomous demand as a whole.

Reverse-Granger causality tests reveal an interesting pattern in the endogeneity of different components. Exports are negatively related to past values of the investment share. This is not unexpected: faster growth of the domestic economy, which usually correlates to a higher investment share, can be a drag on exports because of its effect on domestic inflation. Housing, government investment and consumption are instead positively related to past values of the business investment share, which is consistent with previous empirical work that has found fiscal policy to be often pro-cyclical (Sorensen et al., 2001; Frenkel, 2012) and housing investment to be positively related to macroeconomic conditions (Iacoviello and Pavan, 2011). The null of no Granger-causality, however, can be rejected only for exports and government consumption in our preferred two-way fixed-effects specification.

We interpret these ‘disaggregated’ results as, on the one hand, suggesting that our focus on aggregate autonomous demand is appropriate, but, on the other hand, indicating that endogeneity issues are relevant. Endogeneity should be tackled in a more explicit way in order to provide credible estimates of the effect of autonomous demand.¹⁴

¹⁴ The main potential confounding variable in our analysis is GDP growth, which may drive both autonomous demand and the investment share, resulting in omitted-variable bias. Note that it would be incorrect to deal with this issue by adding GDP growth as a control variable in equation 1. In the short-run, changes in GDP depend on changes in autonomous demand, both mechanically and because of the multiplier effect. And aggregate income growth is precisely the channel through which autonomous demand is expected to influence business investment. The correct way to deal with this problem is to identify changes in autonomous demand that are exogenous to domestic macroeconomic conditions, as we attempt to do in the next Section.

5 – Instrumental variables estimation of the effect of autonomous demand

While our analysis so far controls for country-specific fixed effects, time-varying common shocks (absorbed by the time dummies) and investment share dynamics, it may still be biased by the presence of unobserved time-varying country-specific factors, affecting both autonomous demand growth and the business investment share. Supply side factors and/or institutional changes that simultaneously influence autonomous demand and the investment share may be confounding our analysis. In this Section we employ an instrumental-variables (IV) approach to address these concerns. Our aim is to identify exogenous variation in autonomous demand, that can be used to estimate its causal effect.

5.1 – Three instrumental variables for autonomous demand

We employ three instrumental variables for autonomous demand:

- (1) demand for imports from the largest World economy (the US) weighted by a country's exposure to trade with the US;
- (2) an index measuring the weighted-average openness to trade of a country's main export destinations;
- (3) military spending.

In what follows we define each of these variables and motivate their use as exogenous instruments, before presenting first-stage and 2SLS estimations.

Jack-knifed US import growth \times exposure to the US - Changes in overall US demand for imports, driven by internal dynamics of the US economy, are certainly a major determinant of exports for all countries in our sample. At the same time, there is large variability across countries in the degree of 'exposure' to demand shocks coming from the US. For example, an increase in US demand for foreign products will affect Canada more than Japan, and Japan more than the Netherlands. Our first instrumental variable is based on this logic.

Specifically, for each country i and year t , we calculate the growth rate of US demand for imports, excluding imports from country i . In this way, we exclude changes in US imports that may be directly related to changes in the competitiveness of country i (and therefore might be endogenous). We call this variable 'jack-knifed US imports demand'.

We then multiply this 'jack-knifed US imports demand' variable by the share of the exports of country i that are absorbed by the US. In this way, we take into account the fact that a given increase in US aggregate demand for imports will imply a much larger shock for (say) Canada than for the Netherlands. To avoid endogeneity, we calculate five-year averages of the share of

exports going to the US, and in each year t we use the data for the previous five-year period, rather than for year t .

Formally, this instrument is calculated as:

$$\begin{aligned}\Delta US Demand_{i,t} &= j.k. US import growth \times exposure = \\ &= [\Delta \ln(M_{US,t} - M_{US \rightarrow i,t}) * 100] \times \overline{(X_{i \rightarrow US}/X_i)}_{past}\end{aligned}$$

Where t is time (years); M_{US} are overall US imports; $M_{US \rightarrow i} = X_{i \rightarrow US}$ are US imports from country i (or, equivalently, i 's exports towards the US); X_i is total export of country i ; \overline{X}_{past} is the 5-years average of variable X in the previous 5-years period (not including year t).

When controlling for year effects, identification of the effect of autonomous demand using this instrument comes entirely from cross-country variation in exposure to the US. For example, in the presence of a general rise in US demand for imports in year t , Canada will be impacted much more than the Netherlands. We therefore test whether the investment share will react more in Canada than in the Netherlands during and after year t , as a result of this differential in the intensity of the shock.

The crucial identifying assumption we are making in using this instrument is that *past* exposure to trade with the US [as measured by $\overline{(X_{i \rightarrow US}/X_i)}_{past}$] is exogenous to future changes in the investment share. We believe that this is a reasonable identifying assumption, given that (lagged) exposure to trade with the US is largely determined by geography and by the industry mix that a country has inherited from the past and that is basically fixed in the short-run.¹⁵

The other key assumption is that US aggregate demand is not determined by macroeconomic conditions in its main trade partner countries. This assumption may fail in a small open economy but appears reasonable for a large and relatively close economy like the US.

Obviously, this variable is not available for the United States, therefore our instrumental-variables analysis will focus on the remaining 19 countries.

Weighted average openness to trade of export destinations – Our second instrumental variable is based on the idea that for a country i , a lifting of trade restrictions in its main export destinations can give a boost to exports, and conversely, the erection of trade barriers in key trade partners can depress exports. For each country, we calculate the weighted-average openness to trade of its five main export destinations.

¹⁵ This instrumental variable is similar in its logic to the so-called ‘Bartik instruments’, which have been used extensively in labor economics. Bartik-type instruments attempt to isolate exogenous labor-market shocks at the regional level. They are built as the interaction of (lagged) regional industry shares with national industry growth rates. See Goldsmith-Pinkham et al. (2018) for a recent discussion.

In using this instrumental variable, we are imposing the identifying assumptions that a country's trade policy is not determined by the macroeconomic conditions of its main trade partners. We see this as rather plausible.

As a measure of openness, we use the 'trade restrictions' index calculated by Dreher et al. (2008).¹⁶ This variable is calculated on the basis of four sub-components: hidden import barriers, mean tariff rate, taxes on international trade (as a % of current revenue), and capital account restrictions (see Dreher, 2006 and Dreher et al., 2008 for details). This variable is higher the lower the trade restrictions (which is why we call it an indicator of 'openness'). The five main export destinations of each country i are selected as follows: for each commercial partner k of country i , we calculate the average yearly share of i 's exports absorbed by country k in each year, and then take the average of this share over the whole sample period. We then select, for each country i , the five trade partners with highest shares and calculate a weighted-average of the measure of openness for these five main export destinations, with (fixed) weights proportional to average total population during the sample period.

Military expenditure – While the two instrumental variables described so far are related to exports, military spending is a sizable component of public expenditure that tends to be largely independent of the business cycle.¹⁷ This instrument is imperfect, mainly because increases in military spending may tend to be offset, at least partially, by correspondent decreases in other components of public spending (Yang et al., 2014). However, as we will show presently, in our sample changes in military spending tend to correlate quite strongly with changes in overall public expenditure, suggesting that the crowding-out effect on other components of government spending, while probably present, is far from complete. It is worth noting that, *ceteris paribus*, the negative effect of military spending on other spending components would bias our estimates of the effect of autonomous demand downwards, thus making them more conservative.¹⁸

Of course, the identification assumption underlying the use of this instrumental variable is that changes in national military spending are largely exogenous to the domestic business cycle.

The two-stages least squares (2SLS) estimations that we perform in this Section have the following general form:

¹⁶ The variable 'trade restrictions' is one of the components of the KOF Index of Globalization proposed by Dreher (2006) and updated in Dreher et al. (2008). We downloaded the most updated version of the index from their website, globalization.kof.ethz.ch (accessed in October 2018).

¹⁷ For example, Nakamura and Steinsson (2014) observe that in the US, while the regional distribution of military spending is highly political and thus likely to be affected by local economic conditions, "national military spending is dominated by geopolitical events" (Nakamura and Steinsson, 2014, p. 755).

¹⁸ On the other hand, our estimates based on military spending may be biased upwards if the multiplier of military spending was significantly higher than the multiplier of the other components of public spending.

$$\begin{aligned}
I/Y_{i,t} &= \alpha_i + \delta_t + \sum_{j=0}^p \beta_j \Delta z_{i,t-j} + \sum_{j=1}^p \gamma_j \Delta(I/Y)_{i,t-j} + \varepsilon_{i,t} \\
\Delta z_{i,t} &= \rho_i + \theta_t + \sum_{j=0}^q \varphi_j \Delta US\ Demand_{i,t-j} + \sum_{j=0}^q \pi_j \Delta TPs\ openness_{i,t-j} + \\
&\quad + \sum_{j=0}^q \sigma_j \Delta Milex_{i,t-j} + \sum_{j=1}^p \omega_j \Delta(I/Y)_{i,t-j} + v_{i,t}
\end{aligned} \tag{2}$$

This specification implies that we are using only variation in autonomous demand growth that is induced by changes in our three instrumental variables in order to estimate the effect of autonomous demand on the business investment share. We use the yearly dataset to estimate equations (2), because data on our three instruments is not available on a quarterly basis.

5.2 – First stage estimation: effect of the external instruments on autonomous demand

Before formally estimating our first-stage regression, we plot each instrumental variable against the corresponding component of autonomous demand, in order to provide a transparent preliminary check of the relevance of our instruments (Figures 2 to 4).

Figure 2 reveals a strong positive relation between military expenditure and overall government spending (both taken in yearly growth rates). Figure 3 displays the positive effect of US demand for imports on the exports of other countries. Figure 4 plots the positive relation between exports growth and our measure of export destinations' openness to trade. Specifically, in this case we plot changes in export destinations' openness to trade versus 4-years ahead changes in exports. In this way, we account for the fact that domestic industries may react gradually to changes in trade partners' trade policy.

While the visual evidence of Figures 2 to 4 is only descriptive, it suggests that our instrumental variables are relevant, and for all of them the relation with autonomous demand has the expected sign.

Table 7 reports formal estimates of the first stage regression, with aggregate autonomous demand growth as the dependent variable. We include four lags of each instrumental variable, after having observed that further lags are never significant nor economically relevant, and two lags of the investment share, in order to reflect the 2SLS estimations that we will present briefly.

Specifically, column 1 reports results from a simple pooled-OLS model. Column 2 includes year fixed effects, while column 3 adds also country dummies, and column 4 also controls for the real interest rate and the profit share. For all specifications, the null hypothesis that the

instruments are not related to autonomous demand is rejected at the 1% significance level, confirming that the instruments are relevant.

5.3 – Two-stages least squares estimates of the effect of autonomous demand

Table 8 displays results from the estimation of the IV model described by equations (2) on our yearly panel dataset. We include two lags of autonomous demand and of the investment share in the second stage, based on the usual diagnostic tests and after having checked that further lags are not significant, and four lags of each instrumental variable in the first stage (in terms of equations (2), we are setting $p = 2$ and $q = 4$). This choice of lag length is also consistent with the Granger-causality analysis on quarterly data, where we included at most eight lagged quarters.

For the sake of comparison, the first four columns report estimates from a fixed-effects OLS model, that does not instrument autonomous demand growth. Columns 5 to 8 report the 2SLS estimations, using our three instrumental variables for autonomous demand. For both the OLS and the 2SLS model, we present results from a pooled specification (columns 1 and 5); controlling for year effects (columns 2 and 6); controlling for two-way fixed-effects (columns 3 and 7); controlling for two-way fixed-effects, the profit share and the real interest rate (columns 4 and 8). As in all estimations presented here, we cluster standard errors both by country and year.

We perform a Sargan-Hansen test of overidentifying restrictions to test the validity of our instruments. Rejection of the null hypothesis would indicate that the instruments are not valid. Reassuringly, the p-value for this test varies between 0.32 and 0.75 in our IV specifications, which is consistent with our instrumental variables being exogenous.

Across all specifications, autonomous demand growth has a positive, economically relevant and statistically significant effect on the ratio of business investment to GDP. The null-hypothesis that autonomous demand growth has no effect is rejected at least at the 10% significance level in all specifications (and at the 5% level in all specifications but one). The long-run effect of a permanent increase in autonomous demand growth on the investment share implied by the IV estimations lies between 0.33 and 1.9 points of GDP.

As already discussed, the inclusion of the real interest rate and the profit share as control variables (as done in columns 4 and 8 of Table 8) is an exercise to be interpreted with caution: both variables are endogenous, and this is likely to bias also the coefficients for the effect of autonomous demand. (Although of course it is reassuring that including these two variables does not alter the main results.) Moreover, given that the number of observations per country is much lower than in the quarterly dataset (less than 50 on average, only 23 for some countries), the specifications including country fixed effects may be affected by Nickell bias (Nickell, 1981). For these reasons, our preferred specifications are those in columns 5 and 6, which do not include country effects (thus avoiding Nickell bias) nor endogenous control variables (thus avoiding

endogeneity bias). In these preferred specifications, the long-run effect of autonomous demand is between 1.5 and 1.9 points of GDP.

Figure 5 plots the impulse-response function (IRF) implied by our preferred IV specification (the fixed-effects model with time dummies). This displays the time-path of the effect of a permanent 1% increase in autonomous demand growth on the business investment share, based on the coefficients reported in Table 8. The estimated IRF indicates a gradual increase in the investment share after a permanent positive autonomous demand shock, with I/Y eventually reaching its new (higher) equilibrium.

Of course, the time path of the effect depicted in Figure 5 relies heavily on our parametric specification of the autoregressive process followed by the investment share. We are tracing the time path of the effect of an autonomous demand shock by extrapolating the observed persistence of the investment share into the future. Moreover, this procedure implies that we are simulating the effect of a *permanent* increase in the growth rate of autonomous demand. While this is of primary interest for our analysis, we are also interested in assessing the effect of a temporary increase in the growth rate of autonomous demand.

For these reasons, in the next subsection we present semi-parametric estimates of the dynamic effect of on autonomous demand shock based on local projections (Jordà, 2005). These do not assume any parametric model for the dynamics of the outcome of interest and can be interpreted as tracing the time-path of the effect of a *temporary* increase in autonomous demand growth.

5.4 – Semi-parametric estimates using local projections (LPs)

Our local-projections estimates of the effect of autonomous demand on the investment share consist of a series of regression with the following form:

$$I/Y_{i,t+h} = \alpha_i^h + \delta_t^h + \sum_{j=1}^2 \gamma_j^h \Delta(I/Y)_{i,t-j} + \beta^h \Delta Z_{i,t} + \varepsilon_{i,t+h} \quad \text{for } h = 1, \dots, n \quad (3)$$

We estimate local projections at a 10-years horizon ($n = 10$), using both a simple OLS model (likely biased by endogeneity) and a 2SLS model that uses the three instrumental variables that we have introduced in this Section.

The estimated dynamic effect of autonomous demand obtained from equation (3) does not rely on parametric assumptions about the autoregressive structure of the variables of interest (unlike the dynamic panel models presented so far). Moreover, it estimates the effect of a *temporary* shock to the growth rate of autonomous demand.

The resulting time-path of the effect of autonomous demand is displayed in Figure 6, where panel (a) displays OLS estimations and panel (b) displays 2SLS estimations which control for endogeneity through instrumental variables. In both specifications, a temporary 1% increase in the growth rate of autonomous demand tends to cause a gradual temporary increase in the investment share, with the effect reaching a peak after four years and then gradually reversing. While the effect is positive, significant and remarkably persistent in both the OLS and the instrumental-variables specifications, this analysis suggests that endogeneity tends to lead to underestimation of the effect of interest: at its peak, the effect is around 0.06 percentage points of GDP in the OLS estimation but around 0.25 points of GDP in the 2SLS specification.

6 – Discussion

What are the macroeconomic implications of a positive relation between autonomous demand and the share of business investment in GDP? In what follows, we relate our empirical results to the recently reignited debate on hysteresis (6.1). We then assess the compatibility of our findings with different Macroeconomic models (6.2). We provide here an informal discussion of this latter issue, while a more detailed exposition with some simple formalization is reported in Online Appendix B.

6.1 – The influence of demand on business investment as a source of hysteresis

A growing strand of literature explores the possibility that shocks to actual output have an impact on long-run economic dynamics – referred to as hysteresis (Blanchard and Summers, 1986; Ball, 1999, 2009, 2014; Schettkat and Sun, 2009). Various channels have been investigated: wage-setting asymmetries between insiders and outsiders (Blanchard and Summers, 1986); monetary policy (Schettkat and Sun, 2009); the interaction of shocks with “poor” labor market institutions (Blanchard and Wolfers, 2010); financial and political crises (Cerra and Saxena, 2008); endogenous productivity and R&D technology adoption (Comin and Gertler, 2006); aggregate demand through multiple routes (see various works of Laurence Ball).

Our results are informative for this debate, because they provide evidence in favor of the hypothesis that the effect of demand on capital accumulation is strong enough to be a major potential source of hysteresis. As we have shown, autonomous demand shocks have a sizable effect on the share of productive resources devoted to capital accumulation.

That a higher investment share has implications for long-run output is a result that holds independently of the assumed aggregate production function. Obviously, with fixed-coefficient production, potential output is simply proportional to the capital stock. But the investment share

is relevant for long-run output also under a Neoclassical production function. In the Neoclassical exogenous growth model (Solow, 1956), a higher investment share is associated with a higher equilibrium level of output per capita; in endogenous growth models (e.g. Romer, 1986), a higher investment share is associated with a higher equilibrium rate of growth.¹⁹ Of course, in both exogenous and endogenous Neoclassical growth theory, it is not aggregate demand but exogenous individual preferences ('thriftiness') which determine the investment share, contrarily to our empirical results and ruling out hysteresis.

6.2 – *Autonomous demand and the investment share in alternative theoretical frameworks*

Our empirical findings are helpful in assessing alternative macroeconomic models. Indeed, different models yield starkly different predictions about the effect of demand shocks on the business investment share.

The canonical Neo-Keynesian model - A positive impact of autonomous demand on the business investment share is certainly inconsistent with supply-led models where demand, whether in level or growth terms, does not have a persistent, long-run independent influence. This is the case of the canonical New Keynesian 3-equations model (Carlin and Soskice, 2015; Clarida et al., 1999), in which equilibrium output is supply-side determined. If autonomous demand increases, the Monetary Rule of the model prescribes a raise in the rate of interest, to tame the ensuing inflation. Consequently, private investment is crowded out and its share in GDP decreases. Given that a standard New Keynesian model is unable to explain the results of our empirical analysis, in what follows we turn our attention to alternative approaches.

Classical models - 'Classical' models, like those presented by Duménil and Lévy (1999), Park (2000) and Shaikh (2009), produce results that in this respect are very similar to those of the canonical New Keynesian model. In Duménil and Lévy (1999), the economy is assumed to converge to a 'Classical' equilibrium, with capacity utilization equal to its desired degree and no inflation. For a given level of technology and real wage, the rate of profit is fully determined, and so does the rate of growth, which is assumed to be a function of the profit rate. Along the equilibrium path, a surge in demand generates a degree of utilization above the normal one, and thus inflation. The Central Bank is assumed to react by reducing the money supply (as in Duménil and Lévy, 1999) or by increasing the interest rate, with the consequence of displacing the economy on a new equilibrium path where normal utilization is restored but growth is slower, and the investment share is lower.

While the original formulation by Duménil and Lévy does not consider explicitly autonomous demand, this is introduced by Park (2000) in his version of the model. The

¹⁹ This mechanism can operate directly by affecting capital per worker (Romer, 1986) or through the pattern of technological progress (Lucas, 1988; Romer, 1990). See also Cesaratto (1999) for a critical discussion.

conclusions are similar: an acceleration of autonomous demand leads to a slowdown of the economy and an increase in the share of autonomous demand in GDP, mirrored by a lower share of private investment. The Classical-Harrodian model proposed by Shaikh (Shaikh, 2009) produces analogous results. Only under restrictive conditions increases in autonomous demand growth result in higher investment share and output growth. A surge in autonomous demand usually turns out to be “*too much of a good thing*” (ibid., p. 469).

The Neo-Kaleckian model - Demand-led growth models, in which aggregate demand influences long-run outcomes, are natural candidates to explain our results. Notice, however, that in a baseline Neo-Kaleckian model (Amadeo, 1986) – where aggregate demand only comprises induced consumption and investment – the investment share is supply-side determined, with no role for demand. The ratio of investment to GDP is indeed equal to the capitalists’ marginal propensity to save times the profit share, which are both assumed to be exogenously given. In an otherwise standard Neo-Kaleckian model that includes autonomous demand, on the other hand, autonomous demand growth does have an impact on the investment share, but a *negative* one (as we show in Appendix B). The reason behind this result is that, in these models, capacity utilization is assumed to be flexible in the long-run. Demand shocks are thus fully accommodated by changes in the rate of capacity utilization: a permanent acceleration in autonomous demand would cause a permanently higher rate of utilization. Given that firms, in this framework, do not attempt to restore a cost-minimizing rate of utilization,²⁰ investment growth does not catch up and a lower investment share persists.

Harrodian models – Does a benchmark Harrodian model, of the type presented in Skott (2010), predict a positive effect of autonomous demand shocks on the investment share, consistent with our findings? Peter Skott (2016) argues that it does. Commenting on US time-series results presented in Girardi and Pariboni (2016), he writes that “(...) changes in the growth rate affect the share of investment in income. This result is what a simple Harrodian model would predict: if the utilization rate fluctuates around a constant desired value, an increase in the growth rate must raise the investment-output ratio” (Skott, 2016, note 8, p. 6).

In what follows, we argue that the answer is more nuanced: the simplest version of the Harrodian model that Skott refers to is not consistent with our findings; its ‘Kaldor-Marshall’ extension, however, is arguably able to explain our results, although the implied channels of causality are not fully consistent with some aspects of our empirical analysis.

First, it is worthwhile noticing that Skott is talking about the relation between the *output* growth rate and the investment share, while our empirical results (both in our 2016 article, which Skott refers to, and here) concern the impact of changes in *autonomous demand* growth on the

²⁰ Skott (2012), Cesaratto (2015) and Girardi and Pariboni (2018) discuss critically this assumption, from both a theoretical and an empirical point of view.

investment share. Of course, one can argue that demand growth must be in line with output growth. However, the direction of causality is important, as we will argue presently.

To understand and engage with Skott's argument, we can look at the relation between demand and the investment share implied by the benchmark Harrodian model presented in Skott (2010). In this model, an increase in the profit share raises both the investment share and the growth rate of the economy (see Appendix B for more detail). In this generic sense, Peter Skott is certainly right: the model predicts a positive correlation between demand growth and the investment share. However, in Skott's Harrodian model the *primum movens* is a shift in income distribution in favor of capital. The correlation between demand and the investment share is thus spurious: both variables are driven by a third one (the profit share). The simple Harrodian model that Skott refers to does *not* predict a causal effect of exogenous changes in (autonomous) demand on the investment share (which is what we find in our work). What it predicts is that both demand and the investment share are driven by exogenous movements in the profit share.

A different argument applies to the Kaldor-Marshall extension to the baseline Harrodian model, proposed by Skott in the same article (Skott, 2010). This specification can predict a positive effect of demand shocks on the investment share, consistently with our baseline regressions. In this Kaldor-Marshall model, income distribution is endogenously determined by the rate of growth, with the profit share increasing when the output path accelerates (as in the 'Cambridge Equation' growth models). Therefore, a demand expansion increases the profit share, which in turn causes an increase in the investment share. While the general result is consistent with our findings, however, the implied mechanism is not. In the regressions reported in Tables 6 and 8 we control for the profit share and we still find a positive effect of autonomous demand. If the influence of (autonomous) demand on the investment share worked through (endogenous) changes in the profit share, after controlling for the latter the effect should disappear.²¹

Supermultiplier models - The positive effect of autonomous demand on the investment share is consistent with autonomous demand-led growth models in which capacity adjusts to demand in the long-run. A model of this type – dubbed 'Sraffian Supermultiplier' – has been proposed by Serrano (Serrano, 1995; Freitas and Serrano, 2015). More recently, Allain (2015) and Lavoie (2016) provided similar models, in the form of amended versions of the Neo-Kaleckian model. Fazzari et al. (2018) and Palley (2018) enrich the supermultiplier framework with an explicit consideration of labor market dynamics, while Brochier and Macedo e Silva (2018) integrate it within a stock-flow consistent model.

In these theoretical constructions, a speeding up in autonomous demand is initially accommodated by a degree of capacity utilization higher than the desired one. Restoration of a production carried over with the desired intensity of capital utilization requires that investment,

²¹ It is fair to note that Skott's (2016) comment refers to Girardi and Pariboni (2016), in which we do not add the profit share as a control variable.

for a certain span of time, grows faster than autonomous demand and output, which explains the higher equilibrium investment share. In Appendix B, we provide a formal stylized model drawing on this literature, showing that in this framework a higher growth rate of autonomous demand implies a higher investment share.

Conclusions

In this paper, we have provided evidence of a positive influence of autonomous demand growth on the share of business investment in GDP. According to our results, a 1% permanent increase in autonomous demand growth increases the investment share by more than 1.5 percentage points of GDP in the long-run. This finding appears robust to the use of alternative techniques and specifications.

First, we have employed dynamic panel Granger-causality tests to show that changes in autonomous demand growth tend to be followed by same-sign changes in the share of business investment in GDP. This association is robust to the inclusion of two-way fixed effects, the interest rate and the profit share as control variables.

To tackle endogeneity issues due to influence of macroeconomic conditions on autonomous demand, we have employed an instrumental variables approach. We have used three external instruments for autonomous demand in a country i : US aggregate demand for imports (excluding imports from country i) interacted with the share of i 's exports absorbed by the US; weighted-average openness to trade of the five main export destinations of country i ; military expenditure. Using only variation in autonomous demand that is driven by these three instrumental variables, we confirmed a positive association between autonomous demand growth and the investment share.

The results of these instrumental variables estimations suggest that the positive relation between autonomous demand growth and the business investment share is not spurious but reflects a causal effect of demand on capital accumulation. These findings are also robust to using semi-parametric local projections (Jordà, 2005) instead of dynamic panel models.

Our finding that demand factors affect the share of national output devoted to capital accumulation is relevant for the hysteresis debate. It supports the view that the influence of demand on business investment can be a major source of hysteresis.

More generally, our findings are at odds with macroeconomic models in which the level and the growth rate of potential output are fully determined by supply side forces, as we have showed in our discussion of the canonical New-Keynesian 3-equations model and of the Classical growth model of Duménil and Lévy (1999). They are inconsistent also with those demand-led growth models in which capacity does not fully adjust to demand in the long-run, as the standard Neo-

Kaleckian model. On the other hand, the positive response of the investment share to variations in demand growth is precisely the mechanism which guarantees the convergence of the degree of capacity utilization to its normal level in demand-led models of the Supermultiplier type (Freitas and Serrano, 2015; Lavoie 2016).

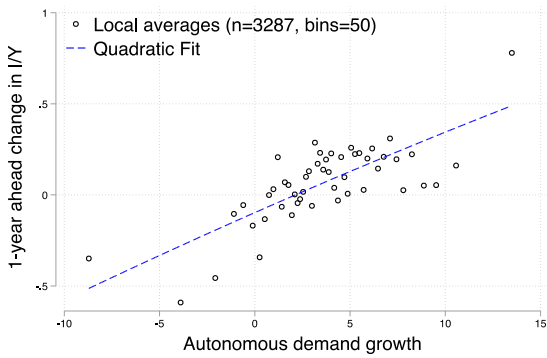
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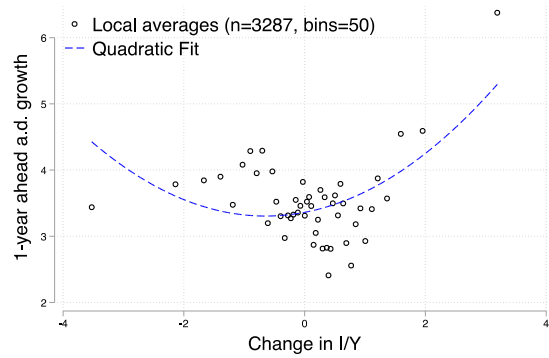
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(a) *Autonomous demand growth vs. 1-year ahead change in I/Y*



(b) *Change in I/Y vs. 1-year ahead autonomous demand growth*

Figure 1 – Relation between autonomous demand and the business investment share (quarterly panel, 1960-2016)

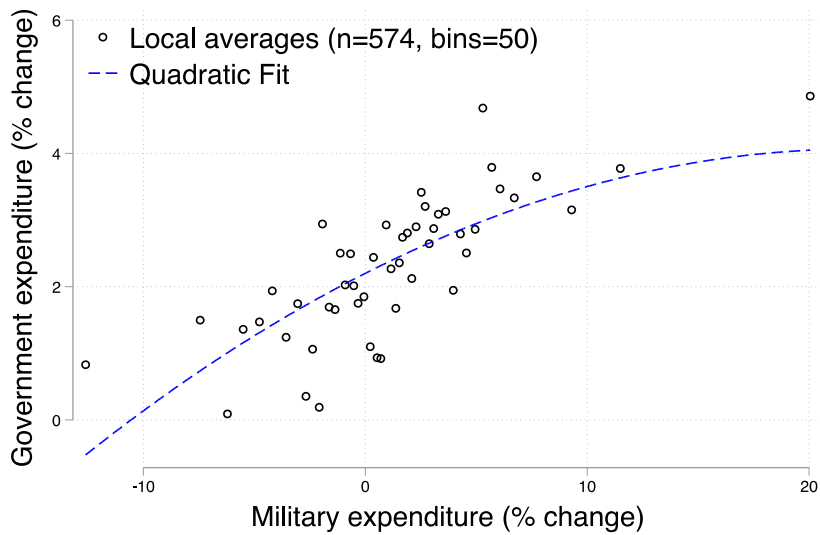


Figure 2 – Military expenditure VS. total government expenditure (yearly panel, 1970-2015)

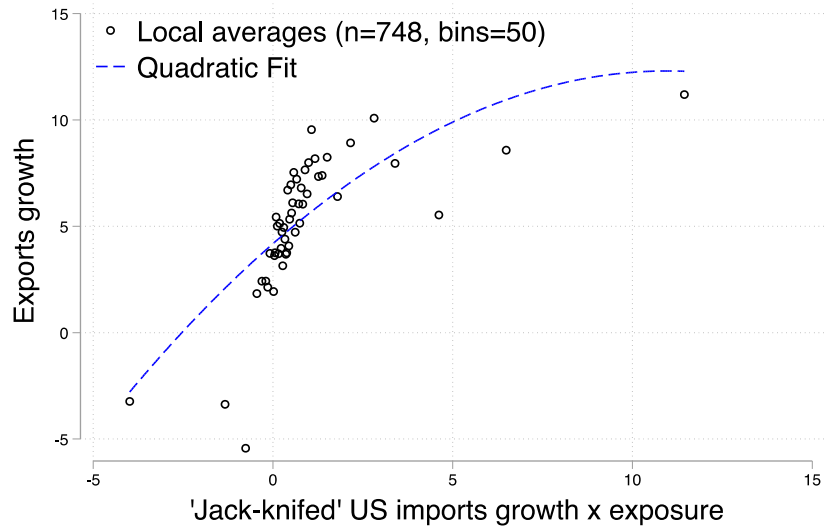


Figure 3— 'Jack-knifed' US import growth x exposure VS. exports
(yearly panel, 1970-2015)

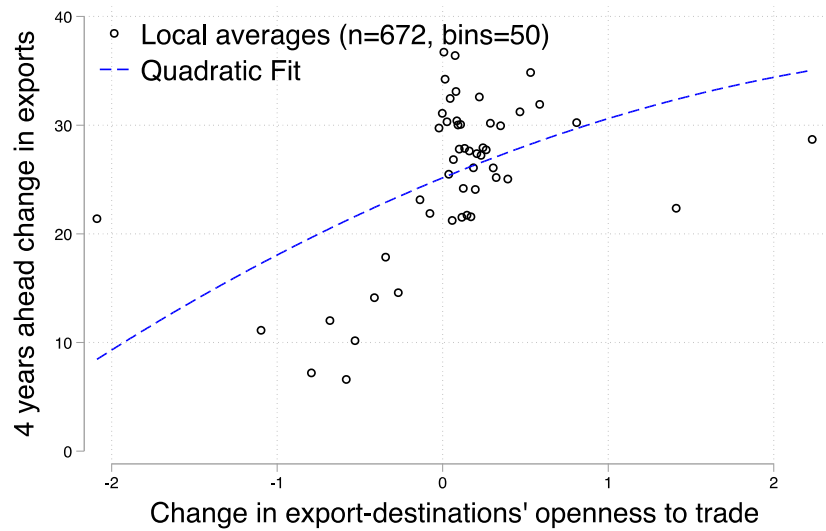


Figure 4— Weighted-average openness to trade of export destinations VS. exports
(yearly panel, 1970-2015)

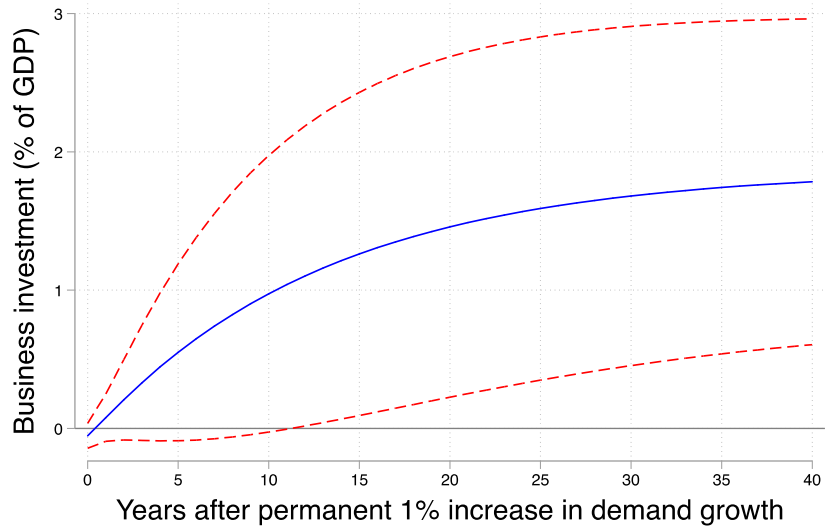
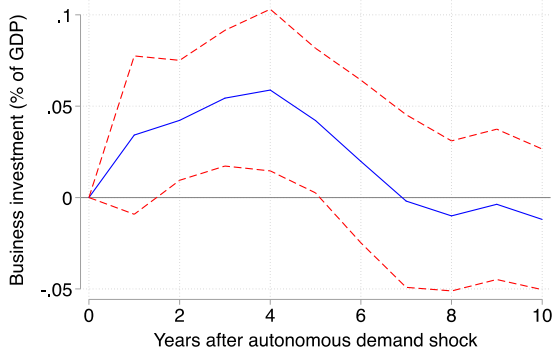
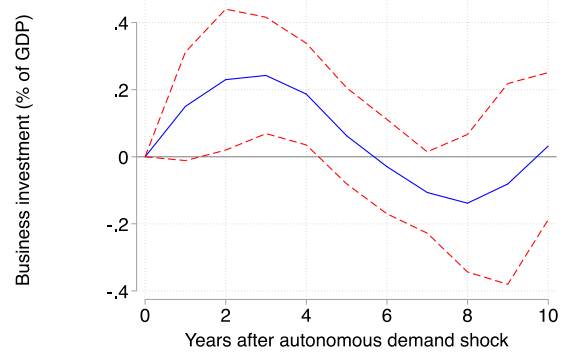


Figure 5— *Dynamic effect of a permanent 1% increase in autonomous demand growth (Instrumental-variables estimation; yearly panel 1970-2015; dotted lines represent 90% confidence intervals calculated from robust standard errors clustered by country and year)*



(a) *OLS estimation*



(b) *Instrumental-variables estimation*

Figure 6— *Dynamic effect of a temporary 1% increase in autonomous demand growth (Local projections; yearly panel 1970-2015; dotted lines represent 90% confidence intervals calculated from robust standard errors clustered by country and year)*

Table 1– Descriptive Statistics

(a) Quarterly data (1960q1-2016q4)					
	n	mean	s.d.	min	max
Business investment share (% of GDP)	3,427	12.0	3.8	2.6	30.1
Autonomous demand (% change)	3,427	0.9	1.8	-10.4	13.7
Real interest rate (%)	3,222	5.7	3.5	-20.5	30.3
Profit share (%)	1,901	32.2	4.1	21.2	49.0
(b) Yearly data (1970-2015)					
	n	mean	s.d.	min	max
Business investment share (% of GDP)	1,022	11.7	3.9	1.3	29.6
Autonomous demand (% change)	1,022	3.7	3.6	-23.8	21.5
Military spending (% change)	972	1.5	5.8	-23.3	34.3
Openness of export destinations (index)	866	4.3	0.2	3.7	4.6
Openness of export destinations (% change)	852	0.1	0.6	-2.5	2.4
Jack-knifed US imports growth x exposure	979	0.9	2.0	-13.4	17.8
Real interest rate (%)	986	2.6	3.4	-17.8	23.0
Profit share (%)	758	30.9	5.8	4.0	46.6

See Appendix A for a description of the dataset construction and sources

Table 2– Panel Unit Root Tests

(test statistics for the null hypothesis of a unit root – quarterly data)

	IPS test	LLC test
Investment Share	-3.38 (p=0.0004)	-2.60 (p=0.0047)
Autonomous Demand Growth	-45.36 (p<0.0000)	-26.67 (p<0.0000)

IPS = Im, Peasaran and Shin (2003); LLC = Levin, Lin and Chu (2002). No. of lags selected by AIC criterion. LLC test requires a balanced panel, so in performing it we restrict the time dimension of the sample to the period for which we have quarterly data for all countries (2002q1-2014q4).

Table 3– Panel Granger causality test between autonomous demand growth (ΔZ) and the business investment share (I/Y) – quarterly data, 1960q1-2016q4

	Dependent variable: business investment share (I/Y)					
	Pooled OLS		Within-countries		2-way FE	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔZ_{t-1}	0.008 (0.011)	0.009 (0.011)	0.004 (0.011)	0.006 (0.011)	-0.002 (0.011)	-0.002 (0.012)
ΔZ_{t-2}	0.028*** (0.009)	0.030*** (0.010)	0.025*** (0.008)	0.027** (0.010)	0.017* (0.009)	0.019* (0.010)
ΔZ_{t-3}	0.032*** (0.005)	0.034*** (0.006)	0.029*** (0.006)	0.031*** (0.006)	0.028*** (0.006)	0.031*** (0.007)
ΔZ_{t-4}	0.020** (0.010)	0.020* (0.010)	0.018** (0.009)	0.017* (0.008)	0.020* (0.011)	0.019* (0.011)
ΔZ_{t-5}		-0.001 (0.005)		-0.003 (0.004)		-0.001 (0.007)
ΔZ_{t-6}		0.009 (0.007)		0.006 (0.007)		0.014 (0.008)
ΔZ_{t-7}		-0.008 (0.009)		-0.010 (0.010)		0.002 (0.011)
ΔZ_{t-8}		-0.007 (0.006)		-0.009 (0.006)		-0.002 (0.007)
F-stat G.-Causality	12.61	18.58	12.09	18.97	5.32	4.14
p-value F-stat	3.56e-05	1.89e-07	4.70e-05	1.59e-07	0.005	0.005
Long-run effect of ΔZ	5.212 (1.338)	5.278 (1.371)	2.202 (0.561)	1.880 (0.601)	1.415 (0.479)	1.795 (0.582)
persistence of I/Y	0.983 (0.003)	0.984 (0.004)	0.965 (0.008)	0.965 (0.008)	0.955 (0.006)	0.955 (0.007)
Country FE	-	-	YES	YES	YES	YES
Year-Quarter FE	-	-	-	-	YES	YES
Observations	3,347	3,267	3,347	3,267	3,347	3,267
Countries	20	20	20	20	20	20

Robust standard errors clustered by country and year-quarter in parentheses. All regressions include a constant term and lags of the dependent variable. Z is the natural log of autonomous demand. I/Y is the ratio of business investment to GDP. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 4– Reverse Causality: Panel Granger causality test between business investment share (I/Y) and autonomous demand growth (ΔZ) – quarterly data, 1960q1-2016q4

	Dependent variable: autonomous demand growth (ΔZ)					
	Pooled OLS		Within countries		2-way FE	
	(1)	(2)	(3)	(4)	(5)	(6)
$(I/Y)_{t-1}$	-0.016 (0.085)	-0.025 (0.080)	-0.047 (0.080)	-0.054 (0.075)	-0.073 (0.073)	-0.080 (0.069)
$(I/Y)_{t-2}$	0.224** (0.094)	0.226** (0.090)	0.210** (0.094)	0.220** (0.090)	0.253*** (0.083)	0.258*** (0.088)
$(I/Y)_{t-3}$	-0.112 (0.096)	-0.140 (0.108)	-0.114 (0.095)	-0.135 (0.105)	-0.042 (0.071)	-0.034 (0.084)
$(I/Y)_{t-4}$	-0.066 (0.065)	-0.078 (0.081)	-0.085 (0.059)	-0.080 (0.079)	-0.109 (0.070)	-0.035 (0.075)
$(I/Y)_{t-5}$		-0.079 (0.096)		-0.082 (0.097)		-0.104 (0.092)
$(I/Y)_{t-6}$		0.073 (0.062)		0.067 (0.061)		-0.005 (0.056)
$(I/Y)_{t-7}$		0.079 (0.060)		0.072 (0.061)		0.059 (0.071)
$(I/Y)_{t-8}$		-0.028 (0.047)		-0.046 (0.046)		-0.042 (0.050)
F-stat G.-Causality	2.056	7.442	10.66	16.33	2.928	5.334
p-value F-stat	0.127	0.00017	0.0001	5.34e-07	0.0483	0.0013
persistence of ΔZ	0.136 0.108	0.247 0.120	0.0378 0.100	0.0806 0.107	-0.241 0.0855	-0.153 0.101
Country FE	-	-	YES	YES	YES	YES
Year-Quarter FE	-	-	-	-	YES	YES
Observations	3,347	3,267	3,347	3,267	3,347	3,267
Countries	20	20	20	20	20	20

Robust standard errors clustered by country and year-quarter in parentheses. All regressions include a constant term and lags of the dependent variable. Z is the natural log of autonomous demand. I/Y is the ratio of business investment to GDP. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 5– Granger causality tests between autonomous demand components and business investment share.

		Granger-causality			Reverse Granger-causality		
		<i>Pooled</i>	<i>Within</i>	<i>2-way FE</i>	<i>Pooled</i>	<i>Within</i>	<i>2-way FE</i>
Aggregate a.d. growth	p-value	3.6e-05	4.7e-05	0.005	0.127	0.0001	0.048
	impact	5.212 (1.338)	2.202 (0.561)	1.415 (0.479)	0.035 (0.024)	-0.036 (0.026)	0.023 (0.016)
Exports	p-value	0.002	0.001	0.490	0.190	2.5e-05	0.0109
	impact	2.610 (0.738)	0.864 (0.290)	0.143 (0.195)	0.016 (0.038)	-0.138 (0.045)	-0.058 (0.051)
Gov. GFCF	p-value	0.129	0.373	0.140	0.004	0.318	0.201
	impact	0.358 (0.466)	0.127 (0.148)	0.184 (0.135)	0.093 (0.023)	0.117 (0.057)	0.146 (0.057)
Gov. cons.	p-value	0.073	0.002	0.475	0.245	0.663	0.002
	impact	-0.564 (1.616)	-0.951 (0.572)	0.257 (0.349)	0.030 (0.013)	-0.007 (0.019)	0.035 (0.010)
Housing investment	p-value	1.7e-05	3.2e-05	0.001	0.006	0.044	0.192
	impact	1.255 (0.496)	0.479 (0.123)	0.295 (0.114)	0.028 (0.046)	-0.074 (0.058)	0.017 (0.074)

This Table summarizes results from a battery of Granger-causality tests performed between each component of autonomous demand and the business investment share. The ‘Granger-causality’ columns report tests in which the investment share is the dependent variable. The ‘Reverse Granger-causality’ columns report tests in which the autonomous component of demand is the dependent variable. Four lags of the dependent and independent variable were included in all regressions.

p-value = *p-value* of the *F*-stat testing the null-hypothesis of no Granger-causality

impact=long-run impact (calculated as $[(\sum_{j=1}^p \beta_j)/(1 - \sum_{j=1}^p \delta_j)]$.); robust standard errors clustered by country and year-quarter in parenthesis.

p-values and *impacts* calculated by estimating equation (1) with 4 lags, with the indicated component as the right-side variable. All autonomous demand components are taken in growth rates.

Table 6 – Robustness test: Panel Granger-causality test between autonomous demand growth (ΔZ) and the business investment share (I/Y), controlling for real interest rate and profit share – quarterly data, 1960q1-2016q4

	Dependent variable: business investment share (I/Y)					
	Pooled OLS		Within-countries		2-way FE	
	(1)	(2)	(3)	(4)	(5)	(6)
ΔZ_{t-1}	0.012 (0.012)	0.028 (0.017)	0.008 (0.012)	0.022 (0.017)	0.001 (0.012)	-0.002 (0.021)
ΔZ_{t-2}	0.035*** (0.009)	0.030** (0.012)	0.031*** (0.009)	0.025* (0.013)	0.024** (0.009)	0.007 (0.014)
ΔZ_{t-3}	0.036*** (0.006)	0.035*** (0.010)	0.033*** (0.006)	0.031*** (0.009)	0.033*** (0.007)	0.020** (0.010)
ΔZ_{t-4}	0.018* (0.009)	0.016* (0.009)	0.016* (0.008)	0.013 (0.009)	0.016 (0.010)	0.006 (0.013)
F-stat G.-Causality	13.36	7.592	11.41	6.661	6.699	2.589
p-value F-stat	2.4e-05	0.001	6.8e-05	0.002	0.001	0.074
Long-run effect of ΔZ	6.291 (1.446)	3.936 (1.198)	2.080 (0.519)	1.124 (0.399)	1.469 (0.505)	0.300 (0.308)
long-run effect RIR	-0.376 (0.293)	-0.493 (0.168)	-0.339 (0.100)	-0.188 (0.067)	-0.307 (0.265)	-0.356 (0.130)
long-run effect PS	- (0.091)	0.383 (0.181)	- (0.131)	0.571 (0.131)	- (0.091)	0.360 (0.091)
persistence of I/Y	0.984 (0.004)	0.972 (0.009)	0.957 (0.011)	0.919 (0.030)	0.949 (0.011)	0.896 (0.033)
Country FE	-	-	YES	YES	YES	YES
Quarter FE	-	-	-	-	YES	YES
Real Interest Rate	YES	YES	YES	YES	YES	YES
Profit Share	-	YES	-	YES	-	YES
Observations	3,138	1,829	3,138	1,829	3,138	1,814
Countries	20	20	20	20	20	20

Robust standard errors clustered by country and year-quarter in parentheses. All regressions control for lags of the dependent variable and for contemporaneous values and lags of real interest rate and profit share. Z is the natural log of autonomous demand. I/Y is the ratio of business investment to GDP. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 7 – First Stage Regressions (yearly data, 1970-2015)

Dependent variable: autonomous demand growth (ΔZ)				
	(1)	(2)	(3)	(4)
ΔMilex_t	0.065** (0.027)	0.096*** (0.026)	0.072*** (0.022)	0.103*** (0.026)
$\Delta \text{Milex}_{t-1}$	0.039 (0.033)	0.079** (0.032)	0.051** (0.022)	0.048*** (0.013)
$\Delta \text{Milex}_{t-2}$	-0.000 (0.027)	0.031 (0.020)	0.010 (0.017)	-0.001 (0.020)
$\Delta \text{Milex}_{t-3}$	0.005 (0.019)	0.033* (0.018)	0.010 (0.016)	-0.003 (0.017)
$\Delta \text{Milex}_{t-4}$	0.001 (0.020)	0.022 (0.023)	-0.002 (0.016)	-0.011 (0.019)
$\Delta \text{US Demand}_t$	0.389*** (0.132)	0.082* (0.043)	0.046 (0.072)	0.069 (0.049)
$\Delta \text{US Demand}_{t-1}$	-0.054 (0.038)	-0.076 (0.060)	-0.097 (0.078)	-0.113* (0.059)
$\Delta \text{US Demand}_{t-2}$	-0.030 (.)	-0.016 (0.055)	-0.034 (0.057)	-0.032 (0.051)
$\Delta \text{US Demand}_{t-3}$	-0.053 (0.035)	-0.014 (0.035)	-0.045 (0.040)	-0.057 (0.041)
$\Delta \text{US Demand}_{t-4}$	-0.121** (0.059)	-0.010 (0.042)	-0.042 (0.039)	-0.041 (0.037)
$\Delta \text{TPs openness}_t$	0.676*** (0.247)	0.088 (0.240)	-0.022 (0.275)	0.025 (0.259)
$\Delta \text{TPs openness}_{t-1}$	0.498 (0.403)	-0.328** (0.166)	-0.449** (0.208)	-0.409 (0.264)
$\Delta \text{TPs openness}_{t-2}$	0.283 (0.276)	0.094 (0.372)	-0.047 (0.371)	0.026 (0.329)
$\Delta \text{TPs openness}_{t-3}$	1.077*** (0.359)	0.156 (0.244)	0.034 (0.291)	-0.005 (0.308)
$\Delta \text{TPs openness}_{t-4}$	0.600 (0.479)	0.711* (0.393)	0.596 (0.369)	0.501 (0.311)
F-Stat Excl. Instruments	72.44	63.62	50.40	68.52
p-value Excl. Instruments	0	2.0e-09	5.3e-07	0
Year FE	-	YES	YES	YES
Country FE	-	-	YES	YES
Real interest rate	-	-	-	YES
Profit share	-	-	-	YES
Observations	691	691	691	604
Countries	19	19	19	19

Robust standard errors clustered by country and year in parentheses. $\Delta \text{US Demand}$ is 'jack-knifed' US imports growth interacted with the share of a country's exports going to the US (see main text); TPs openness is a weighted average of the KOF measure of openness to trade for each country's 5 main export destinations (see main text); ΔMilex is real military expenditure growth. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table 8 – Effect of autonomous demand on the business investment share –Instrumental Variables Estimates
(yearly data, 1970–2015)

	Dependent variable: business investment share (I/Y)							
	OLS				2SLS			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
ΔZ_t	0.015 (0.030)	-0.012 (0.021)	-0.018 (0.019)	0.029 (0.021)	0.118** (0.048)	-0.053 (0.055)	-0.072 (0.057)	-0.031 (0.046)
ΔZ_{t-1}	0.052*** (0.012)	0.051*** (0.013)	0.047*** (0.009)	0.041* (0.023)	-0.005 (0.028)	0.194*** (0.073)	0.182*** (0.061)	0.106*** (0.033)
ΔZ_{t-2}	-0.026* (0.016)	0.001 (0.013)	-0.003 (0.012)	-0.018 (0.017)	-0.049** (0.020)	-0.037 (0.049)	-0.060 (0.057)	-0.001 (0.060)
F-Stat (H_0 =no effect)	21.70	22.04	38.70	30.27	14.52	7.315	9.250	37.02
p-value F-stat	7.6e-05	6.4e-05	2.0e-08	1.2e-06	0.002	0.062	0.026	4.6e-08
p-value overid.	-	-	-	-	0.318	0.707	0.665	0.754
Long-run effect of ΔZ	1.081 (0.499)	1.038 (0.577)	0.225 (0.103)	0.371 (0.090)	1.531 (0.731)	1.873 (0.651)	0.336 (0.420)	0.482 (0.366)
Persistence of I/Y	0.962 (0.008)	0.962 (0.008)	0.885 (0.017)	0.862 (0.031)	0.958 (0.008)	0.945 (0.024)	0.852 (0.034)	0.845 (0.032)
Long-run effect RIR	-	-	-	-0.333 (0.082)	-	-	-	-0.235 (0.148)
Long-run effect PS	-	-	-	0.0975 (0.099)	-	-	-	0.155 (0.094)
Country FE	-	-	YES	YES	-	-	YES	YES
Year FE	-	YES	YES	YES	-	YES	YES	YES
Real interest rate	-	-	-	YES	-	-	-	YES
Profit share	-	-	-	YES	-	-	-	YES
Observations	928	928	928	671	691	691	691	604
Countries	19	19	19	19	19	19	19	19

Robust standard errors clustered by country and year in parentheses. Z is the natural log of autonomous demand. I/Y is the ratio of business investment to GDP. All regressions control for two lags of the dependent variable. In the 2SLS models, autonomous demand is instrumented with ‘jack-knifed’ US demand for imports interacted with the share of exports going to the US (see main text), a weighted average of the KOF measure of openness to trade for each country’s 5 main export destinations (see main text) and real military expenditure. ‘p-value overid.’ is the p-value from a Hausman-Sargan test of overidentifying restrictions. ‘F-stat (H_0 =no-effect)’ is the F-stat for the joint test that all coefficients on autonomous demand growth are equal to zero. *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Online Appendices

Appendix A – Dataset construction and sources

A1. Business investment share

Definition - Ratio of private non-housing gross fixed capital formation over GDP. Both variables taken at constant prices.

Sources- Our main source is the OECD Economic Outlook n.101 (<https://doi.org/10.1787/639d73ee-en>), which provides data on business investment (variable code: IBV) and GDP (variable code: GDPV), both at a quarterly and yearly frequency. For five countries (Austria, Greece, Ireland, Italy and Spain), the yearly IBV series has been taken from older editions of the OECD Economic Outlook (specifically, n.80, 86 and 90, taking for each country the most recent edition in which the series is available), because not reported in more recent editions. For these five countries quarterly data are not available even in the older editions, so we use the approximate measure described below. For Denmark and Belgium, the OECD EO 101 provides yearly series but not quarterly series, but the quarterly series are available in the Economic Outlook editions n.99 and n.97. All quarterly series are taken in seasonally adjusted form.

For some country-years for which IBV is missing, we have calculated an approximated measure from the same database. This approximated measure is calculated as:
[*total investment (ITV) – housing investment (IHV) – government investment (IGV)*]

This is an approximation because government housing investment is implicitly subtracted twice (being included both in ITB and IHV). Given that government housing investment is very small relative to the other variables, this approximation is very close to the exact measure, and displays the same growth dynamics (as shown in Figure A1). We thus used this approximate measure to interpolate or retropolate missing parts of the series, after checking that the level and dynamics of the exact measure and the approximate measure of business investment are closely correlated (Figure A1). We do not perform the interpolation for Denmark, the only country for which we find the two measures to be not closely correlated in some portion of the series (indicating that government housing investment has been large enough in some sample years Denmark, to make our approximated measure significantly differ from the exact measure). For the yearly sample, in some cases the approximate measure is calculated from the corresponding variables in the AMECO database instead of the OECD EO, because not available in the OECD EO. For the quarterly sample, government investment data for Austria, Greece, Ireland, Italy and Spain was taken from Eurostat because not available from OECD EO. Since the Eurostat data are not seasonally adjusted, we performed the seasonal adjustment using the standard X-13ARIMA-SEATS method (the same used on the OECD EO). Eurostat, AMECO and OECD series are indistinguishable for these variables for all country-periods for which they overlap.

A2. Autonomous demand

Definition - Sum of exports, general government final consumption expenditure, general government GFCF and gross housing investment.

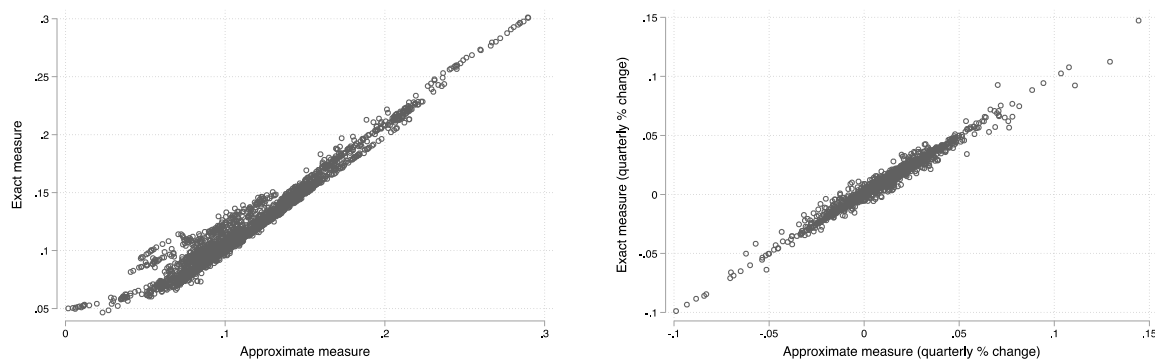
Sources – Also for autonomous demand, our main source is the OECD Economic Outlook n.101. We calculate autonomous demand from OECD EO data as:

$[exports (XGSV) + government\ consumption (CGV) + total\ investment (ITV) - business\ investment (IBV)]$.

Note that, in the absence of Government non-housing investment series, this is the only formula that allows to capture our exact definition of autonomous demand. For countries for which IBV is available in older editions but not in the 101 editions, we used the older editions as described in A1. All quarterly series are taken in seasonally adjusted form. For other country-years for which IBV is missing, we used an approximate measure, similarly to what we did for the investment share. This approximate measure is equal to:

$[exports (XGSV) + government\ consumption (CGV) + government\ investment (IGV) + housing\ investment (IHV)]$

This is an approximation because government housing investment is implicitly counted twice. As government housing investment is very small relative to the other variables, the growth dynamics of this approximate measure are practically indistinguishable from those of the exact measure (as shown in Figure A1), so we interpolate the exact measure with the approximate measure when observations for the exact measure are not available. As already explained in Section A1, in some cases the yearly approximate measure is calculated from the AMECO database (because not available in the OECD EO) and some quarterly government investment data are taken from Eurostat and then seasonally adjusted, because not available in OECD EO.



(a) *Business investment share*

(b) *Autonomous demand (% change)*

*Figure A1 – Comparison of exact and approximate measures
(quarterly panel, 1960-2016)*

A3. Real Interest Rate

Definition – The real interest rate is proxied by the rate of interest on long-term government bonds, adjusted for inflation according to the usual formula.

Sources – The interest rate on long-term government bonds is taken from the IMF International Financial Statistics (IFS) database (<http://data.imf.org/?sk=4C514D48-B6BA-49ED-8AB9->

[52B0C1A0179B](#)). The inflation rate used for calculating the real rate is taken from the IMF IFS for yearly data and from the OECD EO 101 for quarterly data. For some observations that are missing in the IMF IFS data, we have taken the same variables from the OECD Monetary and Financial Statistics, Eurostat (for quarterly data) and AMECO (for yearly data) and used them to interpolate the series, after checking that they are closely correlated both in levels and in percentage changes with the main series.

A4. Profit Share

Definition – Share of gross operating surplus and mixed income (adjusted for the imputed compensation of self-employed workers) in GDP. Formally, it is calculated as:

$$\{[GOPS - (average\ wages * number\ of\ self-employed)] / GDP\}$$

GOPS stands for gross operating surplus and mixed income; average wages are calculated as compensation of employees divided by number of employees.

Sources – Our main source for the profit share series are the OECD Quarterly and Yearly National Accounts, from which we downloaded the variables: Gross operating surplus and mixed income, current prices; compensation of employees, current prices; gross domestic product – income approach, current prices; employees, total and self-employed, total. Quarterly data taken in seasonally adjusted form. For Norway, quarterly data for gross operating surplus and mixed income are available only in non-seasonally adjusted form, so we performed the seasonal adjustment ourselves. In the quarterly dataset, the variable ‘gross operating surplus and mixed income’ for Japan has been downloaded from Cabinet Office, Government of Japan, because unavailable in the OECD NA. When possible, we have extended the data coverage for the quarterly series by reinterpolating the OECD NA with correspondent series retrieved from OECD Economic Outlook 101, OECD Economic Outlook 97 OLIS version, and Eurostat.

A5. Military Spending

Definition – Military spending in real terms.

Source – SIPRI Military Expenditure Database (<https://www.sipri.org/databases/milex/>), 2018 ed.; SIPRI provides nominal series in local currency and US dollars, and real series in constant US dollars, but not in constant local currency. To ensure comparability with our autonomous demand series (which are in constant local currency), we take the nominal series in local currency, and deflate it using the local currency GDP deflator from the OECD EO 101.

A6. Jack-knifed US imports growth weighted by share of exports directed to the US

Definition – This variable is calculated as ‘jack-knifed US imports demand growth’ times ‘lagged exposure’. ‘Jack-knifed US imports demand’ is defined, for each country i , as total US imports minus imports from country i , deflated with the US imports price deflator and then taken in real yearly growth rate. The share of exports directed to the US is calculated for each country i and then transformed in 5-years averages (1960 to 1964; 1965 to 1969; etc.). For each year t , ‘lagged exposure’ is the share of exports going to the US for the most recent five-years period previous to, and not including, year t (for example, for the years from 1965 to 1969, it is the five-years average for the 1960-1964 period).

Sources – US imports data (total and from each country in our sample) and the exports of each country in the sample (total and to the US) are taken from Comtrade, and were downloaded from the World Bank WITS dataset - <https://wits.worldbank.org/>. The US imports price deflator was downloaded from the US Bureau of Economic Analysis (<https://www.bea.gov/>).

A7. Weighted average KOF index of openness to trade for the 5 main export destinations

Definition - The variable ‘trade restrictions’ is one of the components of the KOF Index of Globalization proposed by Dreher (2006) and updated in Dreher et al. (2008). This variable is calculated on the basis of four sub-components: hidden import barriers, mean tariff rate, taxes on international trade (as a % of current revenue), and capital account restrictions (see Dreher, 2006 and Dreher et al., 2008 for details). This variable is higher the lower the trade restrictions (which is why we call it an indicator of ‘openness’). The five main export destinations of each country i are selected as follows: for each commercial partner k of country i , we calculate the average yearly share of i 's exports absorbed by country k in each year, and then take the average of this share over the whole sample period. We then select, for each country i , the five trade partners with highest shares and calculate a weighted-average of the measure of openness for these five main export destinations, with (fixed) weights proportional to average total population during the sample period.

Sources - We downloaded the most updated version of the KOF index from globalization.kof.ethz.ch (accessed in October 2018). Bilateral trade data to identify the 5 main export destinations of each country is taken from Comtrade and downloaded from the World Bank WITS website. Population (used to compute the weights) was taken from the World Bank World Development Indicators.

Appendix B – Autonomous demand and the investment share in alternative theoretical frameworks

This appendix complements the discussion in Section 6.2, providing a more extensive and formal discussion of the predictions of different macroeconomic models on the relation between autonomous demand and the investment share.

B1. The canonical New-Keynesian 3-equations model

The New-Keynesian 3-equation model, labelled sometimes as the ‘New Consensus’ model,²² is “the workhorse model for macroeconomic modelling of economies with an inflation targeting central bank”

²² See Lavoie (2015).

(Carlin and Soskice, 2015, p. xi). In the simplified textbook version provided by Carlin and Soskice (2015), the three equations are:

$$Y_t = A - ar_{t-1} \quad (4)$$

$$H_t = H_{t-1} + b(Y_t - Y_e) \quad (5)$$

$$(Y_t - Y_e) = -bc(H_t - H^T) \quad (6)$$

Equation (4) is a standard IS curve, where A is autonomous demand (comprised here by autonomous consumption and investment plus government spending) and r is the real interest rate. (5) is a Phillips curve: H is the rate of inflation, H_{t-1} is expected inflation, which is equal to lagged inflation with adaptive expectations;²³ $(Y - Y_e)$ is the output gap. This curve is derived from the interaction of wage and price-setting in the economy, while Y_e , equilibrium output, “is the output of the structural or supply-side features of the economy that lie behind the wage-setting and price-setting curves” (Carlin and Soskice, 2015, p. 63). Finally, (6) is a monetary rule and describes the preferred output-inflation combination of an inflation-targeting Central Bank, for any Phillips curve prevailing in the economy, with H^T representing the inflation target; a , b and c are positive parameters.

The underlying logic is simple: if the economy deviates from the supply-side determined, constant inflation equilibrium, the Central Bank reacts and modifies appropriately the policy rate. Hence, in the medium-run we have “a vertical Phillips curve, set at a unique rate of unemployment free from any influence arising from aggregate demand” (Lavoie, 2015, p. 137). The consequences of a permanent positive demand shock are thus straightforward: “the higher autonomous demand needs to be offset by lower interest-sensitive aggregate demand (i.e. investment) if output is to return to its equilibrium level Y_e ” (Carlin and Soskice, 2015, p. 102).²⁴ Given the level of potential output

²³ Inflation inertia is required to have lasting output disequilibria. In the 2006 edition of the book (Carlin and Soskice, 2006, ch. 15), the authors extend the basic model to encompass forward-looking, rational expectation-based Phillips Curves able to produce inflation inertia. Carlin and Soskice (2015, ch. 16) also briefly discuss a ‘hybrid’ Phillips Curve, which “includes forward-looking inflation expectations but acknowledges that inflation appears to be persistent or inertial, i.e. that it depends on lagged values of itself” (Carlin and Soskice, 2015, p. 610).

²⁴ Carlin and Soskice (2006) extend the baseline model by including a forward-looking IS curve. In this case, if a proportion of households - endowed with rational expectations - can lend or borrow (i.e. they can smooth their consumption pattern), aggregate demand shocks can be dampened. Imagine that autonomous demand increases. Households anticipate the Central Bank reaction to the forthcoming output gap and reduce their current consumption, given that a higher interest rate makes future consumption more attractive. In this way, the resulting output gap is lower and the Central Bank does not need to raise the real interest rate as much as in the case of equation (4), to restore equilibrium output. Hence, investment (and the investment share) decreases, but less than in the baseline 3-equation model presented above.

(assumed to be independent of changes in aggregate demand), the share of productive investment in GDP is lowered by an increase in autonomous demand.²⁵

B2 - The Duménil and Lévy Classical model

Very similar mechanisms underlie the model proposed by Duménil and Lévy (Duménil and Lévy, 1999).²⁶ This model features a Keynesian short-run equilibrium, meaning that an independent level of aggregate demand determines output and, being the capital stock given, the equilibrium degree of capacity utilization. However, an adjustment towards a Classical long-term equilibrium is at work, driven by a monetary authority that pursues a zero-inflation target ($H^T = 0$). We can sum the model up by referring to three main equations:

$$g_t^K = \alpha - \beta_1 r_t + \beta_2 u_t \quad (7)$$

$$H_t = \gamma(u_t - u_n) \quad (8)$$

$$\Delta r_t = \varepsilon H_t \quad (9)$$

The first equation is the accumulation function, negatively related to the real interest rate²⁷ and positively to the degree of capacity utilization. The second one is a (non-vertical) Phillips curve, while the third one describes the behaviour of the Central Bank, which is supposed to react to any level of inflation higher than 0 by increasing the real interest rate (α , β_i , γ and ε are positive parameters).²⁸

As can be seen from equations (7)-(9), the model does not consider explicitly autonomous demand. Nevertheless, it is possible to assess the effect of a generic increase in aggregate demand in the model. In the long-term – when prices, the capital stock and the interest rate are allowed to change – the economy converges to a Classical equilibrium, characterized by $u = u_n$, $H = 0$, $\Delta r = 0$.

²⁵ The open-economy version of the 3-equation model (see Carlin and Soskice, 2015, chapter 9) yields a slightly different result. Given that equilibrium home real interest rate is equal to the world interest rate, the adjustment that counteracts a permanent (autonomous) demand shock cannot operate through permanent changes in the real interest rate, as it was the case in a closed economy. The adjusting variable is the real exchange rate and the share of investment in equilibrium output does not change.

²⁶ See Lavoie and Kriesler (2007) for a discussion of the similarities between Duménil and Lévy's contribution and New-Keynesian/New-consensus models.

²⁷ For the sake of simplicity, we adopt here the formalization proposed by Lavoie and Kriesler (2007). In Duménil and Lévy (1999), the negative influence of the interest rate is replaced by a positive influence of the quantity of money. Similarly, the reaction of the Central Bank (equation 9) is expressed in terms of a diminution of the quantity of money when inflation occurs.

²⁸ As Dutt (2011) notices, the main outcomes of Duménil and Lévy's model depend critically on the specific behaviour imposed on the Central Bank.

On the equilibrium path, the (normal) rate of profit is determined only by the state of technology and the given real wage. The equilibrium growth rate itself is a function of the rate of profit (Duménil and Lévy, 1999, p. 704), hence “*the iron law of supply-side accumulation takes over in the long run*” (Lavoie and Kriesler, 2007, p. 595). As Duménil and Lévy themselves make clear (Duménil and Lévy, 1999, p. 705), a demand surge would cause inflation, because incoming new demand is accommodated at first by a degree of capacity utilization higher than the normal one. The Central Bank reacts by raising the interest rate (or by reducing the money stock, as the original example by the authors), dampening in this way the pace of accumulation and causing the share of investment in output to go down.

B3. – Park (2000) and Shaikh (2009)

Park (2000) presents a model where the economy moves along non-steady paths of normal output growth. Autonomous demand is explicitly considered. However, the rate of growth converges – in the stable case - to a long-period warranted rate that can be determined independently from autonomous demand’s level or growth rate.²⁹ This will be given by $g^W = s/v$, which is equal to Harrod’s warranted rate. In this framework, a higher (lower) rate of growth of autonomous demand only implies a slower (faster) convergence to the independently determined long-period warranted rate, i.e. a convergence path characterized by a lower rate of output growth. This is because, in the author’s words, “*as the larger part of aggregate demand is used for non-capacity generating purpose, ceteris paribus, the lesser part thereof will be used for accumulating productive capacity*” (Park, 2000, pp. 9-10). Indeed, given the assumption of continuous normal capacity utilization, the rate of accumulation and the rate of output growth coincide all the time. If the former slows down, the latter adjusts consequently. For what concerns our analysis, it is easy to see that, in Park’s model, a speeding up in autonomous demand is expected to decrease the investment share. Assume that an economy, with a rate of growth of autonomous demand equal to g^{Z_0} and that is converging towards its long-run growth rate, experiences an exogenous shift from g^{Z_0} to g^{Z_1} , with $g^{Z_1} > g^{Z_0}$. This implies that the economy is displaced on a convergence path characterized by a faster evolution of Z and a sluggish output dynamics. The ensuing higher autonomous demand share is mirrored by a lower investment share.

An argument similar to Park’s is advocated by Shaikh (2009), which develops a Classical-Harrodian model in which autonomous components are introduced. The author formalizes the economy’s warranted rate of growth (ibid., p. 469) as

²⁹ This happens because, in Park’s model, stability requires the rate of growth of autonomous demand to be lower than the long-period warranted rate of growth. Hence, over time the share of autonomous demand in output tends to 0.

$$g^W = [s - (G_t + X_t)]/Y_t]u_n/v \quad (10)$$

G is equal to government spending and X to exports, two components that we can consider as comprising autonomous demand. Shaikh claims that an increase in the rate of growth of G and X will be expansionary or contractionary depending on the impact on the $(G + X)/Y$ ratio, that is to say that the equilibrium output rate of growth will increase only if their share in GDP decreases (and implicitly if the share of investment on GDP increases). Within Shaikh's model this happens only under restrictive conditions³⁰ and - for example - an expansionary fiscal policy usually turns out to be "too much of a good thing" (ibid., p. 469) because it lowers the long-run rate of growth.

B4. The Neo-Kaleckian model of growth and distribution

The canonical Neo-Kaleckian growth model (see for example Amadeo, 1986) is built around three main equations:

$$\pi \equiv \Pi \frac{u}{v} \quad (11)$$

$$g^S = \frac{S}{K} = s_\pi \pi = s_\pi \Pi \frac{u}{v} \quad (12)$$

$$g^K = \frac{I}{K} = \alpha + \beta(u - u_n) \quad (13)$$

Equation (11) is simply an accounting identity, representing the rate of profit π as the product of the profit share Π , the degree of capacity utilization u and the inverse of the normal capital-output coefficient v . Equation (12), a saving function normalized by the stock of capital, entails the simplifying assumption that only capitalists save. According to equation (13), accumulation depends on a constant term reflecting animal spirits and/or long-run expected demand (α) and on the discrepancy between actual and normal degree of capacity utilization. We do not need to deal with much formalizations to investigate the behaviour of the investment share in this model. Given that aggregate demand is given by the sum of induced consumption and investment (i.e., there is no autonomous demand), the following condition holds: $I = S = s_\pi \Pi Y$. It follows that

³⁰ If the initial value of autonomous demand growth is g^{z_0} and $g^{z_0} < s/v$, there is a point at which output grows at g^{z_0} and autonomous demand share remains constant at $(Z/Y)^* = s - g^{z_0}/v$. However, in Shaikh's model this outcome is unstable: for values of g^z higher than g^{z_0} , autonomous demand share increases steadily (and the rate of growth of the economy falls steadily); for values of g^z lower than g^{z_0} , on the other hand, the share of autonomous demand tends to 0 (and consequently output rate of growth and investment share steadily increase). In this last case, in the process of convergence of the autonomous demand share towards zero, small increases in autonomous demand growth may not inhibit the steady reduction in Z/Y and the specular increase in I/Y .

$$\frac{I}{Y} = s_{\pi}\Pi \quad (14)$$

Hence (as noted for example by Freitas and Serrano, 2016), the investment share is exogenously determined by two supply-side factors: capitalists' marginal propensity to save and the profit share.³¹ Looking at the equilibrium growth rate of this model and assuming that $(\alpha - \beta u_n) > 0$, as it is more or less implicitly assumed in the Neo-Kaleckian literature (see for example Hein et al., 2012, figure 1, p. 143; Lavoie, 2016, figure 1, p. 180), we have:

$$g^{K*} = (\alpha - \beta u_n) \left(1 + \frac{\beta}{s_{\pi v} - \beta}\right) \quad (15)$$

One might also notice that an exogenous reduction in the profit share (or in the propensity to save) leads to a *higher* equilibrium growth rate and a *lower* investment share, resulting in a *negative* correlation between aggregate demand growth and the investment share.

If we allow for the presence of autonomous components of aggregate demand in an otherwise standard Neo-Kaleckian framework, we can see that an increase in the rate of growth of autonomous demand leads to a *decrease* in the investment share. As showed in Lavoie (2016, p. 179), such an economy converges to the (medium-run) equilibrium position given by

$$u^{**} = u_n + \frac{g^Z - \alpha}{\beta} \quad (16)$$

$$g^{K**} = g^Z \quad (17)$$

It is therefore possible to derive the equilibrium investment share:

$$\left(\frac{I}{Y}\right)^{**} = g^{K**} \frac{v}{u^{**}} = g^Z \frac{v}{u^{**}} \quad (18)$$

The effect of autonomous demand growth on the investment share is given by the following derivative:

$$\frac{d\left(\frac{I}{Y}\right)^{**}}{dg^Z} = \frac{-(\alpha - \beta u_n)v\beta}{(g^Z - \alpha + \beta u_n)^2} \quad (19)$$

³¹ The argument would not change allowing for workers' savings. In that case, the investment share would be determined also by workers' marginal propensity to save.

which is negative as long as $(\alpha - \beta u_n) > 0$. Hence an acceleration in autonomous demand tends to make output grow faster than investment. It is indeed reasonable to expect that initially the output expansion prompted by the increase in g^Z would be accommodated by the existing productive capacity, leading to an increase in the degree of capacity utilization. However, at some point one expects entrepreneurs to try to restore the cost-minimizing rate of capacity utilization: investment would then react more than proportionally, leading to an increase in the investment share. This is assumed not to happen in the Neo-Kaleckian model: after a shock, whatsoever short-to-medium-run equilibrium degree of capacity utilization (in principle free to range between zero and full utilization) persists over time.³² This implies that also the investment share persists at the new lower level.

B5 - Neo-Harrodian models

In a recent contribution, Skott (2016) discusses some findings in Girardi and Pariboni (2016) and comments that “Another finding shows that changes in the growth rate affect the share of investment in income. This result is what a simple Harrodian argument would predict: if the utilization rate fluctuates around a constant desired value, an increase in the growth rate must raise the investment-output ratio.” (Skott, 2016, p. 6). In order to substantiate this claim, it is possible to look at the Harrodian benchmark model presented in Skott (2010), given by, *inter alia*, the following equations:

$$g^S = \frac{S}{K} = s(\Pi) \frac{u}{v} \quad (20)$$

$$g^K = \frac{I}{K} = \varphi(u) \quad (21)$$

$$g^K = \lambda(u - u_n) \quad (22)$$

The saving function (20) is increasing in the degree of capacity utilization (u) and in the profit share (Π). Equation (21) is the long-run accumulation function, with $\varphi'(u) > 0$. The accumulation rate evolves over time according to equation (22).

It is also assumed that Keynesian stability does not hold in the long-run; hence, we have

$$\frac{d^I}{du} = \varphi'(u) > \frac{s(\Pi)}{v} = \frac{d^S}{du} \quad (23)$$

³² See Skott (2012), Girardi and Pariboni (2018) and Cesaratto (2015) for detailed critical discussions.

From the equilibrium condition ($S = I$) it is possible to derive the steady-state solutions³³ for the degree of capacity utilization and the growth rate, which satisfy the conditions:

$$\frac{du^*}{d\Pi} = \frac{s'(\Pi)\frac{u^*}{v}}{\varphi'(u^*) - \frac{s(\Pi)}{v}} > 0 \quad \text{and} \quad \frac{dg^*}{d\Pi} = \varphi'(u^*)\frac{du^*}{d\Pi} \quad (24)$$

From (24), it follows that, *if* there is an increase in the profit share, then the rate of growth increases and so does the investment-output ratio, equal to $s(\Pi)$. This is certainly consistent with a positive correlation between autonomous demand and the investment share, as Skott (2016) argues. However, in Skott's model the *primum movens* of both events is a shift in income distribution in favor of capitalists. The correlation between demand and the investment share is thus spurious in this context: both variables are driven by a third one. Our empirical analysis, on the other hand, has attempted to assess the effect of autonomous demand shocks, keeping everything else (including the profit share, that is indeed a control variable in our analysis) constant. Our finding that *exogenous* changes in autonomous demand *cause* the investment share to increase is thus different from the positive correlation predicted by the Harrodian models that Skott refers to.

B6 - The Sraffian supermultiplier

The main message of the Sraffian supermultiplier model (Serrano, 1995) is that output growth tends to be driven by the growth of the autonomous components of demand. In this model, firms continuously and gradually attempt to reach the normal (cost-minimizing) rate of capacity utilization, so the system is in equilibrium when capacity is normally utilized. In the baseline version of the model (that can be found for example in Cesaratto et al., 2003), output is equal to the product of autonomous demand Z and the so-called supermultiplier³⁴

$$Y_t = \frac{Z_t}{s+m-v(\delta+g_t^e)} \quad (25)$$

s and m are, respectively, the marginal propensities to save and to import. Business investment is assumed to be induced by growth expectations (according to a standard 'accelerator' principle), which can be represented as

³³ As the author makes clear, even in the presence of Harrodian instability "an unstable growth path may provide a good approximation to average outcomes in the medium to long run" (Skott, 2010, p. 115), if the fluctuations in the accumulation rate are bounded. If this is the case, the degree of capacity utilization fluctuates around its normal value and the growth rate fluctuates around the steady-state, warranted rate.

³⁴ As usual in the literature, δ is the rate of capital depreciation; v is the normal capital-output technical coefficient, taken as given in this logical stage of the analysis.

$$I_t = v(\delta + g_t^e)Y_t \quad (26)$$

Where g_t^e represents the entrepreneurs' estimate of the trend growth rate of demand. Entrepreneurs revise their growth expectations as long as they diverge from the actual, realized growth rate, by means of a simple adaptive process:³⁵

$$\dot{g}^e = \gamma(g^Y - g^e) \quad (27)$$

The dynamic system given by (27) and the following equation allows to study the equilibrium results of the model

$$\dot{u} = u_t(g_t^Y - g_t^K) \quad (27)$$

From equations (27) and (27) it is possible to derive the rate of growth (g^Y) and the rate of accumulation (g^K) of the economy:

$$g_t^Y = g_t^Z + \frac{v\dot{g}^e}{s+m-v(\delta+g_t^e)} \quad (28)$$

$$g_t^K = u_t(\delta + g_t^e) - \delta \quad (29)$$

If we plug equations (28) and (29) into the law of movement of the degree of capacity utilization (equation (27)) and impose $\dot{h} = \dot{u} = 0$, we can see that the equilibrium position³⁶ of the model is characterized by

$$\begin{aligned} g^Y &= g^K = g^Z \\ u &= u_n \\ h^{eq} &= (g^Z + \delta)v/u_n \end{aligned} \quad (30)$$

The last equation is of particular interest for the object of this article, because it shows that a permanent increase in the rate of growth of autonomous demand causes, *ceteris paribus*, a higher equilibrium investment share. The economic rationale is straightforward: if a permanent increase in g^Z occurs, the increasing demand will be at first accommodated by a more intense utilization

³⁵ γ is a positive reaction coefficient, assumed to be lower than one.

³⁶ See Freitas and Serrano (2015) for a discussion of the conditions that ensure the dynamic stability of the model.

of the existing capital stock, leading to a degree of capacity utilization $u_t > u_n$. This will trigger an acceleration in investment.³⁷ Output will then grow for a certain span of time at a rate higher than g^Z . At the same time, the adjustment of capacity to demand requires that investment growth is even faster.

When a normal degree of capacity utilization is restored, autonomous demand, output and capital grow in line again. However, the disequilibrium process has been such that the autonomous demand share in output is now lower, while the investment share has increased.³⁸

³⁷ Dutt (2013) provides a further argument in favor of crowding-in effects triggered by public investment (one of the components of autonomous demand in our analysis), based on the complementarity between private and public capital in production.

³⁸ The same conclusion holds for those recent versions of the Neo-Kaleckian model that incorporate autonomous demand and the adjustment of capacity to demand, as for example Allain (2015) and Lavoie (2016).