Structural Changes in Investment and the Waning Power of Monetary Policy

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Abstract

We argue that secular change in both the production and composition of investment goods has weakened private investment's role in the transmission of monetary policy to labor earnings and consumption. We show analytically that fluctuations in the production of investment goods amplify the response of consumption to monetary policy shocks by varying labor income for hand-to-mouth agents. We document three secular changes that weaken this channel: (i) labor's share of value added in investment goods production has declined, (ii) the import share of investment goods has risen, and (iii) the composition of investment has shifted towards components that are less responsive to monetary policy. A small open economy, two agent New Keynesian model calibrated to match these facts implies a 38% and 26% weaker response of labor income and aggregate consumption, respectively, to real interest rate shocks in a 2010's economy relative to a 1960's economy.

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1 Introduction

Growing evidence suggests that monetary policy shocks have smaller effects on economic activity now than in the past, even putting aside issues of an effective lower bound on interest rates. Multiple authors, using various empirical techniques, report declining responsiveness of real output and inflation (Boivin, Kiley, and Mishkin, 2010), consumer durables (Van Zandweghe and Braxton, 2013), employment (Willis and Cao, 2015), and investment (Baldi and Lange, 2019) to U.S. monetary policy shocks.¹

This paper proposes a novel explanation: secular change in both the production and composition of investment goods has weakened private investment’s role in the transmission of monetary policy to labor earnings and consumption. The importance of investment in driving consumption fluctuations in heterogeneous agent models where some households have high marginal propensities to consume (MPC’s) out of labor income has recently been demonstrated quantitatively by Auclert, Rognlie, and Straub (2020) and analytically by Bilbiie, Känzig, and Surico (2020). In such models, investment amplifies fluctuations in consumption by generating labor income for the high-MPC households. The high volatility of investment in U.S. data means that investment fluctuations play an outsized role in driving consumption fluctuations in such calibrated models.

We revisit this mechanism in a parsimonious, two-agent framework that links the consumption of a hand-to-mouth agents to investment and depart from the analyses of the previous authors in studying an open economy environment, revealing an important role for imports. We show that the consumption response of hand-to-mouth agents to changes in real interest rates depends on (i) the responsiveness of investment, (ii) the size of nominal investment spending relative to nominal consumption spending, and (iii) the extent to which investment generates labor income domestically. We label this third term the *domestic labor content*, which we measure from publicly available data. We then show how secular changes have led to declines in (i) and (iii), the responsiveness of investment to shocks to the real interest rate and the domestic labor content, respectively.

We begin by reviewing the composition changes of investment and consumer durables between 1947 and 2020. The most notable change is the rise in “intellectual property products” (IPP) which has grown from less than 1% of GDP around 1950 to nearly 5% of GDP by the beginning of 2020, now accounting for a full fifth of nominal spending on investment and durables. Estimating empirical impulse response functions for each component of invest-

¹See also Boivin et al. (2010) for a summary of an older literature on the declining interest rate sensitivity of the U.S. economy.

ment and durables, we find that IPP is an order of magnitude less responsive to monetary policy shocks than the other components of investment, consistent with firm-level evidence that suggests “intangible” investment spending is relatively insensitive to monetary policy (Caggese and Pérez-Orive, 2020; Döttling and Ratnoski, 2020) and behaves more like a fixed cost (De Ridder, 2019). A simple shift-share analysis implies that the responsiveness of total investment to monetary policy shocks would fall by 20%, under the assumption that the responses of each component are constant over time and as shares change.

Next, we measure the domestic labor content of investment spending and its subcomponents using publicly available Input-Output (I-O) tables. We decompose the domestic labor content into the domestic share of expenditure and the labor share in domestic production, revealing that the domestic labor content of investment and durable goods has fallen from 59 cents on the dollar to 46 cents on the dollar from 1963-2014, driven almost entirely by a decline in the domestic labor content of equipment and durable goods.

To study the effects of these observed trends in a general equilibrium setting, we develop a two-agent, three-sector, small open economy New Keynesian (SOE TANK) model. Households are split between intertemporally optimizing “Ricardian” agents and hand-to-mouth agents, and production is partitioned between a domestic investment good sector, a domestic consumption good sector, and a traded export good sector. Calibrating the investment good sector’s labor and import shares to reflect observed declines in the domestic labor content from the 1960’s to the 2010’s leads to significant dampening of the response of domestic labor income and hand-to-mouth consumption. Importantly, we also show that it matters that the decline in the domestic labor content is concentrated in the investment goods sector: a counterfactual economy where the decline occurs in the consumption goods sector exhibits no dampening of hand-to-mouth consumption. Finally, to derive our headline estimates, we compare “1960s” and “2010s” economies calibrated to match observed trends in the domestic labor content of all final demand components, as well as a modest change in the depreciation rate reflecting the shift in composition to shorter-lived IPP investment. This experiment suggests a decline in the responsiveness of labor income and consumption of 38% and 26%, respectively.

Lastly, we find that a more open economy and the possibility of a stronger exports channel of monetary policy does not offset our findings. The model predicts that in response to an expansionary monetary policy shock, net exports *declines* in the short run and later turns positive. This is because rising demand for imports immediately following the shock more than offsets an increase in exports from a weaker exchange rate. We show that this response

is supported empirically in our estimated impulse responses and as well as by other research such as [Kim \(2001\)](#).

The remainder of the paper is organized as follows. Section [2](#) uses a minimal number of model assumptions to derive a simple decomposition relating the effect of monetary policy shocks on aggregate consumption to the objects we measure in the data, framing our empirical work. Section [3](#) reviews the changing composition of investment, estimates empirical impulse responses of the components of investment, and documents secular changes in the domestic labor content of the components of investment. Section [4](#) builds on Section [2](#)'s assumptions to present a complete two agent, three sector, small open economy New Keynesian model and conducts monetary policy experiments to illustrate how observed changes in the domestic labor content of investment mute the effects of monetary policy on consumption in general equilibrium. Section [5](#) concludes.

1.1 Related Literature

This paper is related to recent work which uses firm-level data to study the response of intangible investment to monetary policy. [Döttling and Ratnoski \(2020\)](#) show that the stock prices of firms with a greater share of intangible capital respond less to monetary policy shocks, citing less of an ability to fund intangible assets with collateral, thereby weakening the credit channel, as well as intangible capital's higher depreciation rate than tangible capital. [Caggese and Pérez-Orive \(2020\)](#) show that firms with more intangible assets depend substantially more on internal savings than collateralized financing, dampening the response of investment to the collateral channel of monetary policy, which [Cloyne, Ferreira, Froemel, and Surico \(2018\)](#) identify as a quantitatively significant channel through which monetary policy affects investment by publically traded firms in the U.S. Our parsimonious general equilibrium model abstracts from these changes in the nature of investment, focusing instead on the decline in the domestic labor content (which does, in fact, deliver the result that investment responds less to monetary policy shocks in general equilibrium).

A large body of related work uses I-O tables to study the changing production structure of investment goods. [Herrendorf, Rogerson, and Valentinyi \(2020\)](#) show that investment is increasingly produced in the service sector, and [Hubmer \(2020\)](#) studies changes in the labor content of production for various categories of U.S. final demand going back to 1982 as part of his exploration of the decline in the aggregate U.S. labor share, including investment. The growth implications of the increasing importance of imports in satisfying domestic investment demand has been studied by [Cavallo and Landry \(2018, 2010\)](#) while

House, Mocanu, and Shapiro (2017) provide evidence that positive shocks to the demand for investment goods result in substantially higher imports. We depart from these studies by bringing in additional data to extend our analysis with I-O tables back to the 1960s and by focusing on the implications for the transmission of monetary policy. For a related study which uses I-O tables to study the implications for optimal fiscal policy in the presence of households with heterogeneous marginal propensities to consume, see Flynn, Patterson, and Sturm (2020).

Finally, this paper is related to a growing body of work on the importance of indirect effects in the transmission of monetary policy in heterogeneous-agent New Keynesian models (Alves et al., 2020; Kaplan et al., 2018). We diverge from this literature in our focus on documenting secular change in the transmission of monetary policy, which leads us to abstract from many of the model features that prove important for determining the level of the consumption response to monetary policy, such as the distribution of profits and incidence of changes in aggregate labor income across different types of agents.

2 Investment and Consumption with Hand-to-Mouth Agents

This section clarifies both the role of investment in amplifying the effects of monetary policy shocks on consumption and how this role is dampened by the decline in the labor share of investment goods, thus motivating our empirical analyses in section 3.4 and section 3.3. This section also highlights the critical assumptions behind the numerical results we present in Section 4, which contains a full description of the general equilibrium model.

Consider a model with a unit mass of infinitely-lived households indexed by i wherein a share of households χ are hand-to-mouth, meaning they cannot save and earn only labor income. We call these “Keynesian” households. The remaining share $1 - \chi$ we call “Ricardian” households who can save in bonds or capital. Within each type, all households solve the same optimization problem and thus choose the same consumption. We can thus write aggregate consumption (C_t) as a weighted average of consumption across the two types, using $C_{k,t}(i)$ to denote individual Keynesian or hand-to-mouth consumption and $C_{r,t}(i)$ to denote individual Ricardian consumption:

$$C_t = \int_0^\chi C_{k,t}(i) di + \int_\chi^1 C_{r,t}(i) di = \chi C_{k,t} + (1 - \chi) C_{r,t}$$

where we use the fact that $C_{k,t}(i) = C_{k,t}$ for all Keynesian households and $C_{r,t}(i) = C_{r,t}$ for all Ricardian households. We also assume that the quality and quantity of labor supplied is identical across all households i , so that all earn the same labor income.² Letting W_t be the real wage and N_t be aggregate labor supply, aggregate consumption demand is:

$$C_t = \chi W_t N_t + (1 - \chi) C_{r,t}, \quad (1)$$

which reflects the fact that a share χ of real labor income is turned immediately into consumption by the hand-to-mouth agents. We further assume that Ricardian agents satisfy the following intertemporal optimality condition in all time periods: letting R_t be the gross real interest rate at time t ,

$$u'(C_{r,t}) = \beta R_t E_t[u'(C_{r,t+1})].$$

Solving this standard Euler equation forward, observe that Ricardian consumption today depends only on the expected path of R_t and the long-run value of consumption (which we assume is unaffected by monetary policy).³ Thus, (1) states that aggregate consumption C_t , given a path of real interest rates pinning down $C_{r,t}$, depends on how *labor income* responds to real interest rates – assuming the share of hand-to-mouth agents is strictly positive ($\chi > 0$).

The relationship of real labor income to real interest rates depends on the economy's production structure. We assume different sectors produce each final demand component: domestic investment and durables consumption, I_t , domestic nondurables and services consumption, C_t , and exports, X_t . Using P_t^k , P_t^c and P_t denote the nominal price in home currency of investment, consumption and exports, respectively, define real investment as $INV_t \equiv P_t^k I_t / P_t^c$ and real exports as $EXP_t \equiv P_t X_t / P_t^c$, obtaining

$$W_t N_t = dlc_t^I INV_t + dlc_t^x EXP_t + dlc_t^c C_t \quad (2)$$

where each dlc_t^j denotes the (potentially time varying) *domestic labor content* for sector j . The domestic labor content is defined as the nominal quantity of labor income generated domestically from a dollar of final demand of sector j . As we will see in later sections, the

²Identical labor supply is a common assumption in heterogenous agent models with sticky wages, which allow for idiosyncratic labor income risk by multiplying identical labor supply by a scalar idiosyncratic productivity term; see e.g. [Auclert et al. \(2020\)](#). Allowing for fixed productivity differentials across types would introduce complexity without qualitatively changing the analysis here. See Section 4 for details.

³Log-linearizing this equation, as we do in Section 4, this statement is equivalent to the insight from the literature on the forward guidance puzzle that current and expected deviations of the real interest rate from the natural rate are the sole determinant of consumption in standard representative agent models where the Euler equation takes this form; see [McKay et al. \(2016\)](#) and [Del Negro et al. \(2015\)](#).

domestic labor content can be expressed as $(1 - m_t^j)(1 - \alpha_t^j)$, where m_t^j is the import share for sector j , and $(1 - \alpha_t^j)$ is the labor share of domestic production for sector j .

Substituting the above equation for labor income into (1) and rearranging yields

$$C_t = \frac{\chi dlc_t^I}{1 - \chi dlc_t^c} INV_t + \frac{\chi dlc_t^x}{1 - \chi dlc_t^c} EXP_t + \frac{1 - \chi}{1 - \chi dlc_t^c} C_{r,t}. \quad (3)$$

To decompose the effects of monetary policy in the model, consider a sequence of expected, gross real interest rates $\{\mathbb{E}_t[R_{t+j}]\}_{j=0}^\infty$ for which our model will yield some equilibrium outcome for C_t and the other endogenous variables. How does C_t change in response to an incremental change in the current gross real interest rate R_t while holding R_{t+j} fixed for $j \geq 1$? Allowing for investment (INV_t) and exports (EXP_t) in equation (3) to be functions of R_t , and assuming that the domestic labor content of each sector (dlc_t^j) does not respond much to monetary policy, we take logs and take the derivative of aggregate consumption with respect to the log of the gross real interest rate, such that for any sequence of expected rates, $d \ln R_t$ is the incremental difference between realized and expected log interest rates in period t .⁴

$$\begin{aligned} \frac{d \ln C_t}{d \ln R_t} &= \frac{\chi dlc_t^I}{1 - \chi dlc_t^c} \times \frac{INV_t}{C_t} \times \frac{\partial \ln INV_t}{\partial \ln R_t} \\ &+ \frac{\chi dlc_t^x}{1 - \chi dlc_t^c} \times \frac{EXP_t}{C_t} \times \frac{\partial \ln EXP_t}{\partial \ln R_t} \\ &+ \frac{1 - \chi}{1 - \chi dlc_t^c} \times \frac{C_{r,t}}{C_t} \times \frac{\partial \ln C_{r,t}}{\partial \ln R_t}, \end{aligned} \quad (4)$$

where $d \ln X_t$ is the deviation of logs of variable X to the baseline in which there were no shocks to the path of expected interest rates $\{\mathbb{E}_t[R_{t+j}]\}_{j=0}^\infty$. Thus, the response of consumption can be decomposed as a weighted average of the response of real investment, exports, and Ricardian nondurables consumption to shocks to the real interest rate.

To understand our concern with investment, note that recent evidence provided by [Cloyne, Ferreira, and Surico \(2020\)](#) suggests that in practice the response of non-durables and services consumption with respect to interest rates for households who are not borrowing constrained ($\frac{\partial \ln C_{r,t}}{\partial \ln R_t}$) is trivial in magnitude relative to e.g. investment or durables (see their figure 3). The exports component plays a quantitatively important role but much less so than investment in the US for two reasons. First, the response of exports to interest rates is weaker than the response of investment and durables by nearly an order of magnitude,

⁴Section 4's model assumes both Cobb-Douglas production and that each factor earns its marginal product, implying constant labor and import shares and hence a constant dlc^j for each sector j .

as we will later show empirically. Second, the US is relatively closed, so that the nominal ratio of exports to non-durables and services consumption ($\frac{EXP_t}{C_t}$) is less than half that of investment and durables ($\frac{INV_t}{C_t}$). Thus in any calibration of a two-agent model of the class described here which fits these empirical facts, including the model presented and solved numerically in Section 4, the contribution of investment to the general equilibrium response of consumption to real interest rates will be significant.

The next section presents evidence that both the response of investment to real interest rates $\frac{\partial \ln INV_t}{\partial \ln R_t}$ and its multiplier $\frac{dlc_t^I}{1-\chi dlc_t^C}$ have fallen between 1963 and 2014.⁵

3 Empirical Findings

We document both that the composition of investment is shifting towards components that are less responsive to monetary policy and that the domestic labor content of investment goods is declining. Section 3.1 describes the data sources. Sections 3.2 and 3.3 break investment demand into its components and show that an increasing share of investment spending is classified as “Intellectual Property Products”, which are quite unresponsive to monetary policy. Section 3.4 documents that domestic labor content of investment goods has declined, due to both a rising import share and falling labor share of value added, and that these changes are concentrated in the production of equipment and durable goods.

3.1 Data

Composition of Investment We obtain quarterly data on the components of investment and durable goods from 1947-2020 from the National Income and Product Accounts (NIPA).

Monetary Policy Shocks We use the narrative shock series constructed by Romer and Romer (2004) and updated by Wieland and Yang (2020) from 1967-1998, which Section 3.3 describes in more detail.

Domestic Labor Content To compute the domestic labor content of various components of final demand over time, we use a new series of annual Input-Output (I-O) tables released

⁵Another fact that implies weakened monetary policy is the shift towards a services economy, which shows up here as a decrease in $\frac{INV_t}{C_t}$. We do not discuss this here purely because it is not a novel observation: that a declining share of interest-sensitive sectors in output may imply weaker monetary policy is well understood, as pointed out recently in e.g. Summers and Stansbury (2019). Though it is worth noting that this channel is not present in a representative agent economy (to see this, set $\chi = 0$).

by the BEA in 2016. These tables have a consistent treatment of investment (in particular, for IPP investment) which is critical for our purposes.⁶ We also use the import ratios from the BEA’s annual Use tables in constructing the domestic total requirements (Leontief inverse) tables for each year. As noted in [Horowitz and Planting \(2009\)](#), the BEA’s source data does not allow the BEA to determine how imported commodities are distributed across using industries, and so we impute these as described below. Finally, a shortcoming of the annual BEA tables is that labor payments in each production sector are reported only beginning in 1997.⁷ Therefore we rely on [Jorgenson, Ho, and Samuels \(2017\)](#) for consistent estimates of payroll shares by industry from 1963-2014.

3.2 Changes in the Composition of Investment from 1947-2020

Throughout this paper, we include consumer durables in our definition of investment, as both the commodity composition of durable goods and their responsiveness to monetary policy closely resemble that of equipment investment. The commodity composition can be seen in Table 1. A similar argument applies to residential investment, and we accordingly include residential investment in our measure of investment.⁸ Therefore, we will often refer to equipment and durables together, and we will similarly group residential investment with investment in non-residential structures, which we collectively refer to as structures. When including durables and housing, gross nominal investment has maintained a relatively constant share of nominal GDP around 25%⁹.

Figure 1 shows the changing gross nominal spending on three aggregated subcomponents of private investment and durables as a share of GDP: equipment and durable goods, structures (residential and nonresidential), and intellectual property products. Equipment and durables had been roughly 15% of GDP for most of the post-war period until a discrete drop

⁶For details on the history and construction of these tables, see [Lyndaker et al. \(2016\)](#); for a summary, see section 11.1 of [Eldridge et al. \(2020\)](#).

⁷In the more detailed tables published every five years, labor’s share of value is reported starting in 1982 as noted by [Hubmer \(2020\)](#).

⁸This is also partly driven by data limitations in the annual I-O Use tables, which do not distinguish between durables and non-durables consumption or residential and non-residential structures investment. We thus consider “structures” investment as a single category, and create a conservative estimate of durables consumption by assuming that commodities from certain categories (such as autos) allocated to consumption are durables. This leaves us with a conservative underestimate for the durables share of consumption relative to e.g. the NIPA estimates. See Table 1 for details.

⁹Many authors have documented that *net* investment has been declining as a share of GDP. Part of this discrepancy is due to the rising depreciation share of nominal GDP, which has risen from 12% to approximately 16% in the time period studied here, as measured by the BEA consumption of fixed capital. The BEA account code is A262RC.

Table 1: Selected Commodity Composition of Final Demand Components, 1997-2018

Commodity	Durables	Equipment	Structures	IPP
Computers	13.2	18.5	0.0	0
Motor vehicles, bodies and trailers, and parts	35.4	20.0	0	0
Machinery	1.4	19.1	0	0
Other transportation equipment	3.3	4.7	0	0
Electrical equipment, appliances, components	5.8	2.2	0.4	0
Furniture and related products	7.2	2.9	0.0	0
Miscellaneous manufacturing	15.4	3.9	0	0
Motion picture and sound recording industries	5.4	0	0	6.3
Wholesale	0	13.3	0.2	2.1
Construction	0	0	76.4	0
Real estate	0	0	10.1	0
Support activities for mining	0	0.1	8.3	0
Misc. Prof., Sci., Tech. services	0	3.9	0.2	49.6
Computer systems design & related services	0	1.5	0	23.6
Publishing industries, includes software	12.7	0	0	11.7
Other Commodities	0	9.8	4.4	6.8
Total	100	100	100	100

Each entry is the share of expenditures of final demand component i (column) spent on commodity j (row), averaged from 1997-2018. We assign commodities used in personal consumption expenditures to durable goods according to whether similar goods are reported in the BEA fixed asset tables, and all commodities considered that we classify as durable are included in this table. The commodity composition of consumer durable goods thus classified most closely resembles that of equipment, though there is some commonality with IPP in the use of “Publishing Industries” and “Motion picture and sound recording industries” commodities.

following the Great Recession, to about 13-14% of GDP. Structures, combining both residential and non-residential decline from approximately 9-10% of GDP to near 7% of GDP. Gross nominal private investment in intellectual products have risen from below 1% of GDP to nearly 5% of GDP. A more detailed figure further decomposing the components can be found in the Appendix (see Figure [A.1](#)).

3.3 Responsiveness of Investment Components to Monetary Policy Shocks

Investment spending is typically one of the most responsive components of GDP to monetary policy shocks. However, not all components of investment respond similarly. To the extent

Figure 1: Compositional Shifts among Investment and Durables, 1947-2020

(a) Nominal Investment Shares with Linear Trend Lines

(b) IPP Shares of Investment

Equipment includes computers in addition to industrial equipment, transportation equipment, etc. Intellectual Property Products (IPP) has risen sharply as a share of Private Fixed Investment, largely due to increases in Software and Research and Development spending. All Data from NIPA Table 5.3.5. except Consumer Durables which is from Table 2.3.5.

that interest rates affect investment, one would predict that long-lived investments with slow depreciation may be more interest-sensitive. To the extent that collateral values are important for financing investment (Cloyne et al., 2018), types of investment that are difficult to collateralize may respond less to changes in collateral prices due to monetary policy. This suggests that the composition of investment matters for the overall response of investment.

We estimate impulse response functions of different components of investment to the narrative monetary policy shocks constructed by Romer and Romer (2004) and updated by Wieland and Yang (2020). To calculate these, we use the following single-equation regression framework as in Romer and Romer (2004): for endogenous variable Y_t (e.g. the level of real software investment) and exogenous shock variable x_t ,

$$y_t = \alpha_0 + \alpha_1 \times trend_t + \sum_{l=1}^L \beta_{y,l} y_{t-l} + \sum_{j=1}^J \beta_{x,l} x_{t-j} + \sum_{s=1}^4 \gamma_s D_{s,t} + \mu_t \quad (5)$$

where y_t is the log difference of Y_t and the $D_{s,t}$ are quarterly dummies used to deseasonalize the data. Following the arguments in Baek and Lee (2020), we choose the maximum lag length of our exogenous shocks $J = 12$ quarters to be the maximum horizon for our impulse response functions and use the BIC to select L subject to the restriction $L \leq J$. Following e.g. Cloyne et al. (2020), our specification allows for a linear time trend variable $trend_t$ (though in practice the BIC rarely selects this specification). We calculate one and two standard error bands using Monte Carlo methods as in Romer and Romer (2004) and use the same sample period of years 1968 to 1998 for reasons we will soon discuss.

Figure 2 plots the impulse response functions of various components of investment. Panels (a), (b), and (c) show the response of residential investment, non-residential structures, and equipment which peak at -15, -5, and -10 percentage points, respectively. In contrast, the response of intellectual property products bottoms out at -1 percentage point. Panels (e) and (f) show the response of durable goods and non-durable goods, demonstrating that the response of durable goods is a similar order of magnitude as equipment and other structures, while non-durables exhibit a much weaker response. The response of PCE services, not shown here, is similarly small.

How much weaker is the aggregate investment response to monetary policy today, given observed shifts in the composition of investment spending? The most natural exercise, which we present in the Appendix Figure A.2, involves splitting the sample and estimating the effect of monetary policy before and after some date. While the point estimates do suggest monetary policy has become weaker, we hesitate to emphasize these results for the following

Figure 2: The cumulative effect of a 1% increase in the Federal Funds Rate on real investment and consumer goods spending, in percentage points. “Time” is quarters after the shock. One and two standard error bands are plotted, calculated as in [Romer and Romer \(2004\)](#). The sample period is 1969-1996 inclusive, as in that paper. See text for estimation details.

reasons: first, low power and large standard errors make it difficult to read too much into the large differences in point estimates, since it is well-known that much of the variation in our policy shock series comes from the early period. Second, qualitative differences between the two series raise some concerns that endogeneity in the monetary policy shock series we use may be a greater problem in the later subsample.¹⁰ In short, it is not clear that the narrative shock series consistently captures exogenous variation in the Federal Funds rate over the entire post-war period, complicating any interpretation Figure A.2 as evidence that the power of monetary policy has diminished.

These concerns motivate the following exercise, which uses impulse response functions estimated on the original time period from [Romer and Romer \(2004\)](#): note that aggregate, real investment and durables spending, $INV_t \equiv P_t^k I_t / P^c$, is the sum of L components D_t^l ,

$$INV_t \equiv \sum_{l=1}^L D_t^l,$$

where in practice the D^l include several categories of spending on equipment and IPP investment, non-residential structures, durables, and residential investment all deflated by P_t^c .¹¹ We may always write percent changes as

$$\frac{INV_{t+\tau} - INV_t}{INV_t} = \sum_{l=1}^L \left(\frac{D_{t+\tau}^l - D_t^l}{D_t^l} \right) \frac{D_t^l}{INV_t},$$

where the right hand side demonstrates a relationship between changes in the components of investment and aggregate investment spending. Thus, estimated responses for each component of investment (inclusive of durables) to monetary policy imply a response for aggregate investment which depends upon the initial share of each component at the time of the shock.

Approximating percentage changes in D^l with the difference in logs, we can estimate the effect of monetary policy on each component using the procedure outlined above.¹² Assuming

¹⁰The identification in [Romer and Romer \(2004\)](#) rests on the assumption that no new information is incorporated into the FOMC's policy decisions between the creation of the Greenbook forecasts and the policy meeting itself. This assumption may be more grossly violated in the later sample; thus, Figure A.2 also considers a specification of equation (5) which replaces the narrative shock series x_t with the high-frequency shock series from [Nakamura and Steinsson \(2018\)](#) when available, with little effect on the results.

¹¹Specifically, we use the finest-available categories for equipment and IPP investment in NIPA table 5.3.5, in addition to non-residential structures, residential investment, and finally consumer durables from NIPA table 2.3.5, and then deflate by core PCE (Fred series PCEPILFE).

¹²Note that we use a different definition of real investment spending than in the Figure 2, using core PCE as a common deflator across investment types, both to align more closely with the right hand side of equation (4) and to permit aggregation using nominal shares.

that these responses have not changed over time, Figure 3 plots implied impulse response functions for a 1960s economy (with the $\frac{D_t^I}{INV_t}$ set to the values observed in $t = 1960q1$) and compares it to the implied impulse response function in a modern economy, where $\frac{D_t^I}{INV_t}$ set to the values observed in $t = 2020q1$. This simple shift-share exercise suggests that the peak effect of monetary policy on investment has fallen from -7.5% to -6.0%, a 20% decline. This reflects the rising share of IPP investment, from zero to roughly a fifth of nominal investment spending, which is nearly unresponsive to monetary policy.

Figure 3: The cumulative effect of a 1% hike in the Federal Funds Rate on aggregate spending on investment and consumer durable goods. Two standard error bands are plotted, calculated as in [Romer and Romer \(2004\)](#). See text for estimation details.

3.4 Falling Domestic Labor Content of Equipment and Durables

The previous section investigated how the changing composition of investment may affect the response of aggregate investment to monetary policy shocks, $\frac{\partial \ln INV_t}{\partial \ln R_t}$. This section explores changes to the transmission of investment to hand-to-mouth consumption, $\frac{\chi dlc_t^I}{1 - \chi dlc_t^C}$, focusing on the numerator: the domestic labor content of investment dlc_t^I .

We calculate the domestic labor content for each final use component i (equipment, NDS,

etc.) using the BEA Input-Output tables, performing a procedure similar to that of [Hubmer \(2020\)](#). The domestic labor content can be computed as:

$$dlc_t^i = \sum_k \omega_{ikt} \theta_{kt}^L,$$

where ω_{ikt} is the quantity of gross industry output from industry k demanded from a dollar of purchases of final demand component i , and θ_{kt}^L is industry's k ratio of wage payments to gross output. ω_{ikt} is computed taking into account the full input-output structure of production, as well as the use of imported intermediates. The full derivation of ω_{ikt} is in Appendix A.2. Using a similar formula, we can compute the domestic value added share of final expenditure i as

$$v_t^i = \sum_k \omega_{ikt} \theta_{kt}^v,$$

where θ_{kt}^v is the value added share of gross output in industry k . To prelude the Cobb-Douglas production functions we will impose shortly, define the labor share of domestic value added $1 - \alpha^i$ of final demand component i to be:

$$(1 - \alpha_t^i) = dlc_t^i / v_t^i.$$

Denote the import share for final demand component i to be m^i . With simple rearranging, and noting that the import share $m^i = 1 - v^i$, we can rewrite the domestic labor content as:

$$dlc_t^i = (1 - \alpha_t^i)(1 - m_t^i).$$

As demonstrated in [Hubmer \(2020\)](#), these empirical shares can be derived as an equilibrium outcome in an economy where industries produce with a CES production technology and take the output of other industries as intermediates. For our purposes, Cobb-Douglas production suffices.¹³

The top panel of Figure 4 plots the domestic labor content for investment (using the broad definition that includes durable goods and residential investment) and consumption (nondurables and services, henceforth NDS) from 1963-2014. Recall that the interpretation of this value is for every dollar spent on final investment or final consumption, how many

¹³See [Jones \(2011\)](#) for a proof that in a competitive input-output economy where the producing industries operate with a Cobb-Douglas production technology in capital, labor, and intermediates, then production aggregates into an aggregate Cobb-Douglas production, where the factor proportions are a function of the industry-specific factor proportions.

cents are paid in domestic payroll. At the beginning of this period, every dollar of final expenditure on investment generated 59 cents of domestic payroll. By the end of the sample, the domestic labor content was only 46 cents on the dollar, representing a 22% decline. Over the same period, the domestic labor content of NDS fell only from 52 cents to 48-49 cents.

The bottom panel of Figure 4 performs a similar calculation for each component of investment separately. This plot shows that the decline in the DLC of investment is entirely due to the decline of the DLC for equipment and durable goods. Since equipment and durable goods account for nearly half of all gross nominal investment expenditure, the decline of the DLC for equipment and durables brings the investment-wide average down.

In Figure 5, we plot the decomposition of the DLC into the labor share of domestic production and the share of domestic expenditure: $dlc^i = (1 - \alpha^i)(1 - m^i)$. Figure 5(a) shows that the decline in the domestic expenditure share is driving the decline in the DLC for investment goods, and the domestic share of expenditure for NDS has changed very little since 1963. Figure 5(b) shows that the labor share in both investment and NDS was flat to slightly increasing from 1963 to around 2001, after which point the labor share declines in both components, though more dramatically in investment.

Looking into the components of investment, Figure 5(c) shows that all of the decline in the domestic expenditure share is accounted for by equipment and durable goods. Structures and intellectual property products show almost no increase in use of imports. Finally, figure 5(d) shows the domestic labor share of each component. The labor share in the domestic IPP production has been rising over time, while it has fallen in both structures and equipment and durables.

The following section derives a small-open-economy, three-sector, two-agent New Keynesian model calibrated to match these observed declines in the domestic labor content. We will use this model to evaluate how the responsiveness of labor income and consumption to real interest rate shocks changes.

4 General Equilibrium Response to Monetary Policy Shocks in an SOE TANK Model as the DLC Falls

This section describes a simple small open economy New Keynesian model with two agents constituting a specific case of the analysis in Section 2. We log-linearize the model around its non-stochastic steady state and study the perfect-foresight response of the economy to real interest rate shocks to demonstrate how a decline in the domestic labor content of invest-

Figure 4: The Domestic Labor Content of Non-Durables and Services and components of Investment

(a) Domestic Labor Content for NDS and Investment & Durables

(b) Domestic Labor Content by Investment Category

The top panel shows that the domestic labor content of non-durables and services has declined by 4 percentage points, from 0.53 to 0.49, while the domestic labor content of investment and durables has fallen by 13 percentage points, from 0.59 to 0.46, a 22% decline. The bottom panel plots the domestic labor content of each component of investment, revealing that the decline is driven by the falling domestic labor content of equipment and durables, which falls by over 40% from 1963-2014.

Figure 5: Breakdown of Domestic Labor Content into “Domestic Share of Expenditure” and “Labor Share of Domestic Production” by sector, [1963-2014]

These figures demonstrate that the majority of the decline in the domestic labor content for both investment and consumption has resulted from a rising share of imports, particularly for the production of investment goods.

ment reduces the effects of monetary policy on labor incomes and consumption in general equilibrium.¹⁴ We follow [Auclert, Rognlie, and Straub \(2020\)](#) in placing nominal rigidities in wage setting rather than in prices, as this allows simple calculations of relative prices of goods produced in different sectors and abstracts from issues regarding the cyclicity of monopoly profits.

4.1 Households

There are two types of households, as described in Section 2. Households $i \in [0, 1]$ maximize

$$E_t \left[\sum_{\tau=0}^{\infty} \beta^{t+\tau} \left(\frac{C_{i,t+\tau}^{1-\sigma}}{1-\sigma} - \varphi \frac{N_{i,t+\tau}^{1+\eta}}{1+\eta} \right) \right],$$

where $N_{i,t} = \int_0^1 N_{i,k,t} dk$ are hours (or workers) supplied in k tasks from household i . However, only Ricardian households, of which there are measure $1 - \chi$, can borrow and save in several assets; $B_{i,t}$ denotes the quantity of riskless, home bonds in zero net supply held by (Ricardian) household i at time t , and similarly $A_{i,t}$ denotes the quantity of foreign bonds denominated in foreign currency, each of which matures at $t + 1$. S_t is the nominal exchange rate defined as home/foreign currency. The nominal, riskless return on the home bond is R_t (recycling notation from Section 2) and on the foreign bond R_t^f . Households can also acquire shares $\nu_{i,t}$ at price Q_t in a representative firm which accumulates capital, K_t , and pays out profits as dividends each period, D_t ; we normalize total shares $\int_0^1 \nu_{i,t} di = 1$. Maximization is thus subject to:

$$\begin{aligned} C_{i,t} + \frac{B_{i,t}}{P_t^c} + \frac{S_t A_{i,t}}{P_t^c} + \frac{Q_t \nu_{i,t}}{P_t^c} &= \frac{S_t R_{t-1}^f \Phi_{t-1} A_{i,t-1}}{P_t^c} + \frac{R_{t-1} B_{i,t-1}}{P_t^c} + \frac{(Q_t + D_t) \nu_{i,t-1}}{P_t^c} \\ &+ \int_0^1 W_{k,t} N_{i,k,t} dk, \end{aligned}$$

where the price of the final consumption good P_t^c is implicitly used as the numeraire for the real wages $W_{k,t}$. The variable Φ_t is the “premium” which foreign assets pay over home assets, and depends on aggregate borrowing: letting P_t denote the price of exports and

¹⁴See [Auclert, Rognlie, and Straub \(2020\)](#) and [McKay, Nakamura, and Steinsson \(2016\)](#) for examples of this approach; since the linearized model features multiple equilibria given a real interest rate path, uniqueness is achieved by requiring that the economy returns to steady state at some point in the distant future. Strictly speaking it is not necessary to log linearize the model first, but when solving the nonlinear version of the model the results for the impulse response functions are nearly unchanged.

$a_t^f \equiv \int_0^1 S_t A_{i,t} / P_t di$, with

$$\Phi_t = \exp \left(-\phi_a (a_t^f - a_{ss}) \right),$$

where the parameter a_{ss} determines the steady-state of a_t ; in practice this is zero and $\phi_a > 0$ is calibrated to be small so that the risk premium term is small in equilibrium, as this term is included only to solve some well-known technical issues that arise in linearized, small open economy models (Schmitt-Grohé and Uribe, 2003). The representative capital firm maximizes the present value of dividends subject to convex investment adjustment costs. Letting $\Lambda_t \equiv \Pi_{j=0}^{t-1} R_j^{-1}$, P_t^k be the nominal price of investment, and $\hat{R}_t^k$ be the nominal rental rate, the firm chooses a path for investment I_t to maximize:

$$E_t \left[\sum_{\tau=1}^{\infty} \Lambda_{t+\tau} D_{t+\tau} \right] = E_t \left[\sum_{\tau=1}^{\infty} \Lambda_{t+\tau} \left(\hat{R}_{t+\tau}^k K_{t+\tau-1} - \frac{\phi}{2} \left(\frac{I_{t+\tau}}{K_{t+\tau-1}} - \delta \right)^2 P_{t+\tau}^k K_{t+\tau-1} - P_{t+\tau}^k I_{t+\tau} \right) \right]$$

subject to the capital accumulation constraint

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

While Ricardians have FOCs for consumption, bond holdings and shares in the capital goods firm as shown above, the measure χ of hand-to-mouth (or “Keynesian”) agents only have the condition that they consume all available labor income:

$$C_{i,t} = \int_0^1 W_{k,t} N_{i,k,t} dk.$$

Since all Keynesian agents obtain the same labor income in equilibrium, we write their consumption $C_{i,t} \equiv C_{k,t}$.

4.2 Union Wage Setting

Unions for each task k set nominal wages each period $\hat{W}_{k,t}$ subject to convex adjustment costs and downward-sloping demand from a labor packer who bundles labor in tasks k into aggregate labor N_t , and sells at nominal wage $\hat{W}_t$ to all final goods firms. Unions call upon their members to supply equal amounts of labor to meet demand, so $N_{i,k,t} = N_{k,t}$. Further, since each union faces the same problem, they always set the same wage and face the same

labor demand, so

$$\begin{aligned} N_{k,t} &= N_t \\ \hat{W}_{k,t} &= \hat{W}_t. \end{aligned}$$

Unions set wages to maximize average expected utility of their members, putting equal weight on each household. This yields the following nonlinear wage Phillips curve: denoting gross nominal wage inflation as $\pi_t^w \equiv \hat{W}_t/\hat{W}_{t-1}$,¹⁵

$$\pi_t^w(\pi_t^w - 1) = \frac{\epsilon}{\psi} \left(\varphi N_t^{1+\eta} - \frac{\epsilon - 1}{\epsilon} W_t N_t ((1 - \chi) C_{r,t}^{-\sigma} + \chi (N_t W_t)^{-\sigma}) \right) + \beta \pi_{t+1}^w (\pi_{t+1}^w - 1),$$

where ϵ is the elasticity of substitution across tasks and ψ parameterizes the costliness of changing wages. In practice, we choose φ to normalize steady state labor supply $N = 1$ and choose ψ and ϵ to imply a slope of the linearized wage Philips curve equal to 0.1, as in [Auclert et al. \(2018\)](#). Since labor income is the same across types, aggregate consumption demand takes the form given in equation (1) above.

4.3 Investment, Consumption and Export Goods Producers

All final goods production is Cobb-Douglas: letting K_t^j , L_t^j and M_t^j be the capital, labor and imported intermediates used in sector j at time t ,

$$\begin{aligned} I_t &= (Z_t (K_t^i)^{\alpha_i} (N_t^i)^{1-\alpha_i})^{1-m_i} (M_t^i)^{m_i} \\ C_t &= (Z_t (K_t^c)^{\alpha_c} (N_t^c)^{1-\alpha_c})^{1-m_c} (M_t^c)^{m_c} \\ X_t &= Z_t (K_t^x)^{\alpha_x} (N_t^x)^{1-\alpha_x}, \end{aligned}$$

where we assume the export sector does not use imports; see the diagram in Figure 6. Each sector is perfectly competitive and sets prices flexibly, so that the labor share of value added and import shares of gross output in each sector j are constant and given by $1 - \alpha_j$ and m_j , respectively. These are calibrated to match the estimates in section 3.4.

Our small open economy assumptions are the following: the foreign currency price of imports, P^f , is constant. The home currency price is determined by the exchange rate:

$$P_t^m = S_t P^f$$

¹⁵For a derivation, see Appendix C1 of [Auclert et al. \(2018\)](#).

Figure 6: The production structure of Section 4's small open economy model.

Foreign demand for exports m_c^f is a fixed share of foreign income in foreign currency, Y^f , which we also assume is fixed. Thus export demand is

$$P_t X_t = S_t m_c^f Y^f.$$

All markets for labor, capital, and imports M_t clear:

$$\begin{aligned} N_t &= N_t^i + N_t^c + N_t^x \\ K_{t-1} &= K_t^i + K_t^c + K_t^x \\ M_t &= M_t^i + M_t^c. \end{aligned}$$

Finally, the balance of payments which equates income from home's foreign assets and exports with purchases of new assets and imports can be derived by aggregating across households' budget constraints:

$$P_t a_t^f + P_t^m (M_t^c + M_t^i) = P_t X_t + \frac{S_t P_{t-1} a_{t-1}^f R_{t-1}^f \Phi_{t-1}}{S_{t-1}} - \frac{\phi}{2} \left(\frac{I_t}{K_{t-1}} - \delta \right)^2 P_t^k K_{t-1},$$

and nominal GDP is defined as:

$$GDP = P_t^c C_t + P_t^k I_t + S_t (P_t^x X_t - P_t^f M_t^c - P_t^f M_t^i).$$

A Taylor rule closes the model and selects a zero-inflation steady state; however, going forward, we will consider shocks to the path of real interest rates as our policy experiment of interest and so the specification is irrelevant. Table 2 summarizes the choices of the parameters used in the following exercises.

4.4 The Perfect-Foresight Response to a Transitory Real Interest Rate Shock

Log linearizing around a non-stochastic steady state yields a convenient, static expression decomposing any percentage deviation in hand-to-mouth consumption from steady state into a weighted average of three components: for any variable x_t , let x be the steady state of x_t and $\hat{x}_t \equiv \log x_t - \log x$,

$$\underbrace{\widehat{C_{k,t}}}_{\text{Hand-to-Mouth Consumption}} = \underbrace{\frac{N^x}{\Omega} \left(\frac{P_t^x X_t}{P_t^c} \right)}_{\text{Real Exports}} + \underbrace{\frac{N^i}{\Omega} \left(\frac{P_t^k I_t}{P_t^c} \right)}_{\text{Real Investment}} + \left(1 - \frac{N^x}{\Omega} - \frac{N^i}{\Omega} \right) \underbrace{\widehat{C_{r,t}}}_{\text{Ricardian Consumption}}, \quad (6)$$

where $\Omega \equiv 1 - \chi(1 - \alpha_c)(1 - m_c)$ and N^x and N^i are the steady state labor shares in the export and investment sectors, respectively; see Appendix A.4 for a derivation. Equation (6) clarifies how the response of hand-to-mouth consumption to a given path of real interest rates – which pins down the Ricardian consumption response – depends on both the interest sensitivity of investment and exports *and* the weights. Since we calibrate the model to ensure that investment is the most responsive component of monetary policy, lowering the domestic labor content of investment weakens monetary policy’s effect on hand-to-mouth consumption because we use less labor in the investment good sector, lowering N^i and thus putting less weight on investment in the right hand side of equation (6).

In all the figures that follow, we plot the response of each variable with respect to a transitory, one hundred basis point (1%) real interest rate shock at $t = 1$.¹⁶ The responses are plotted in terms of log deviations from steady-state. First, Figure 7(a) plots the response of consumption for three different calibrations which raise first m_i and then also α_i that approximate the changes we document in the U.S. data from the 1960s to the present, raising

¹⁶Results where we allow the shock to follow a persistent AR(1) process are qualitatively similar.

Parameter	Value	Description	Notes
β	.99	Households' Discount Factor	Calibrated to steady state real annual interest rate of 4%
σ	2	Inverse Elasticity of Intertemporal Substitution	
η	1	Inverse Frisch Elasticity of Labor Supply	
φ	Varies	Scales level of disutility from labor	Chosen to normalize steady-state $N = 1$.
χ	0.3	Share of hand-to-mouth agents	Taken from Kaplan, Violante, and Weidner (2014) .
ϕ_a	0.01	Responsiveness of the risk-premium to aggregate NFA	Chosen to be small as in Schmitt-Grohé and Uribe (2003) .
a_{ss}	0	Steady-state NFA	
ϕ	5	Level of convex capital adjustment costs	
δ	0.03	Depreciation rate of capital	
ϵ	10	Elasticity of substitution across tasks	Calibrated to a markup of 10% for unions
ψ	100	Level of convex wage adjustment costs	Sets the wage Phillips-curve's slope to 0.1 as in Auclert et al. (2018) .
α_j, m_j	Varies	Capital share and import share of sector j	Calibrated to estimates in Section 3.4.
$m_c^f Y^f / P^f$	Varies	"Real" exports in terms of foreign currency import price	Chosen to normalize steady-state terms of trade $P^m / P = 1$.

Table 2: Parameters for Section 4's quarterly, small open economy New Keynesian model.

the import share m_i by 20 percentage points from .1 to .3 and the capital share α_i from .33 to .4. The aggregate consumption response and the hand-to-mouth consumption response are compared, where by design the aggregate consumption response weakens across calibrations only because the hand-to-mouth consumption response weakens (since the consumption of Ricardian agents is entirely determined by σ and the real interest rate, which are held fixed across calibrations).

Figure 7(b) plots the response of each of the three right hand side components in equation (6): real investment, real exports, and real Ricardian consumption. Changes in the steady state labor shares N^j are also reported, revealing that the aggregate consumption response falls both because of the diminished general-equilibrium response of investment and because of changes in the weights in equation (6). In this experiment, the model predicts that the peak, on-impact response of hand-to-mouth consumption to a monetary policy shock is 34% smaller in the calibration with the lower domestic labor content, and that the aggregate consumption response is 21% smaller. Note, however, that a substantial portion of the decline in hand-to-mouth consumption is because the response of investment is itself dampened. Under a counterfactual in which the investment response remained unchanged as the import share m_i and labor share of domestic value added α_i change, the on-impact response of hand-to-mouth consumption to a real interest shock would only be dampened by 17%.¹⁷ The remainder is explained by a dampening of the investment response due to the relative price of capital, as wages are sticky but import prices and capital goods prices are flexible. In response to an interest rate shock, the exchange rate depreciates, making imports more expensive, and capital goods also become more expensive. As the exposure of the marginal costs of investment good production to price-flexible factors of production (K_t and M_t^i) increases, the responsiveness of investment to interest rate shocks declines.

Figure 8 reports responses for other variables in the model which helps understand how it is possible that the exports response does not change as we increase the “openness” of the model economy: net borrowing increases, so that the short run effect of expansionary monetary policy is actually to deteriorate the trade balance, in contrast to the traditional Mundell-Fleming model which suggests that net exports should rise due to the weakened exchange rate. Expansionary monetary policy shocks do indeed appear to deteriorate the trade balance in the short run for the U.S. as demonstrated in Cloyne et al. (2020) with narrative shocks and Kim (2001) using a VAR approach. We replicate these empirical findings in Figure 9 which plots the cumulative response of exports and imports to a contractionary

¹⁷This can be calculated by using equation (6), plugging in the values for N^i corresponding to $m_i = .3$ and $\alpha_i = .4$, but using the impulse response of investment under the baseline values of $m_i = .1$ and $\alpha_i = .33$.

shock using the same approach as in Section 3.3.

Would the results be different if the rise in imports had occurred in non-durables and services, as opposed to investment? Figure 10 demonstrates that it is important that the rise in imports is concentrated in the production of investment goods, rather than consumption goods; in a counterfactual world where we raise the import share of consumption, m_i , the effects of monetary policy on the economy are relatively unchanged.

Turning now to the effect of the rise of intangible investment, Figure 11 shows that weakening responsiveness of investment to real interest rate shocks can be implemented in this model by changing the depreciation rate of capital. According to the BEA, the fraction of consumption of fixed capital to GDP has risen from approximately 12% in the 1960's to 16% in the 2010's. Raising our quarterly depreciation rate from .03 to .0375, our model gives a dampening of the response of investment in percent deviations by 20%, matching the shift-share changes estimated in section 3.3. A dampening of the investment response by 20% corresponds to a 13% dampening in the response of hand-to-mouth consumption (and a 7% decline in aggregate consumption response).

Finally, to obtain our headline result, we calibrate the model to match the average α_j and m_j for the years 1963-1969, with a depreciation rate of $\delta = 0.03$ and then α_j and m_j for the years 2010-2014, with a depreciation rate of $\delta = 0.0375$.¹⁸ Figure 12 compares the effects of a monetary policy shock in each economy, showing these changes imply an on-impact decline in the aggregate consumption response to monetary policy by 26%, driven by a 38% decline in the hand-to-mouth consumption response.

We conclude that the decline in the domestic labor content of investment may have significantly dampened the general equilibrium effects of monetary policy.

5 Conclusion

This paper has documented that secular change in both the production and composition of investment goods has weakened private investment's role in the transmission of monetary policy to labor earnings and consumption. Due to a declining domestic labor content of investment, investment fluctuations no longer amplify the effects of monetary policy shocks on consumption as they once did. Moreover, the investment response to monetary policy is likely weaker as well due to an increasing share of "intangible" investment in final demand.

These results may have important implications for optimal monetary policy. If the

¹⁸Using smaller values in the literature for depreciation rates does not materially change our results.

quantity of conventional monetary policy needed to stimulate output is greater in open, de-industrializing modern economies, then policy makers should expect to find themselves constrained by the effective lower bound (ELB) on interest rates more frequently, all else equal. Further study of the implications in a more realistic, quantitative model and for dynamics surrounding ELB episodes is on our agenda, and may shed additional light on the observed tendency for open, increasingly “service based” economies to find themselves constrained by the ELB in recent decades.

Figure 7: Response of H2M Consumption and Determinants as Investment's Import Share m_i Rises and Labor Share $1 - \alpha_i$ Falls.

(a) Consumption Response

(b) Determinants of Hand-to-Mouth Consumption

Each figure displays the response of a particular variable to a negative, transitory 1% shock to the real interest rate in different calibrations of Section 4's small open economy New Keynesian model; see text for details. Each line reflects a different calibration as indicated in the legend. The first, solid line is calibrated to be illustrative of a 1960s economy; the second dotted line changes the import share to its modern value and then the dashed line changes also the labor share to its modern value.

Figure 8: Each figure displays the response of a particular variable to a negative, transitory 1% shock to the real interest rate in different calibrations of Section 4's small open economy New Keynesian model; see text for details. The calibrations are the same as in Figure 7.

Figure 9: Impulse Reponse of Exports and Imports to Romer & Romer Shocks

These figures plot the cumulative response of exports and imports to a contractionary shock to the federal funds rate. Imports are negative in the early periods, and exports respond negatively with a substantial lag. Imports reverse after ten quarters, leaving the longer-run net exports effect to be negative. This indicates that in response to a rise in real interest rates, net exports rises. In the other direction, an expansionary shock worsens the trade balance in the short run, and the trade balance responds positively over longer horizons. This is consistent with other studies of the effect of monetary policy on net exports; see e.g. [Cloyne et al. \(2020\)](#)'s Figure 13 and [Kim \(2001\)](#).

Figure 10: Comparison of H2M Consumption Response: Import Rise Concentrated in Consumption vs. Investment Goods

Each figure displays the response of a particular variable to a negative, transitory 1% shock to the real interest rate in different calibrations of Section 4's small open economy New Keynesian model; see text for details. The solid blue line is the same calibration as in Figure 7. The dotted line changes consumption's import share (counterfactually) while the dashed line changes investment's import share, illustrating that the importance of the fact that the rise in imports is concentrated in investment good production in obtaining our results.

Figure 11: Dampening Investment Response by Raising Depreciation

(a) Consumption Response

(b) Determinants of Hand-to-Mouth Consumption

This figure demonstrates that a weakening of the response of investment due to compositional changes can be viewed in this model as a rise in the depreciation rate. By raising the quarterly depreciation rate from .03 to .0375, the responsiveness of investment and hand-to-mouth consumption decline by 20% and 13%, respectively

Figure 12: Impact of Monetary Policy in a 1960s economy vs. a 2010s economy

(a) Consumption Response

(b) Determinants of Hand-to-Mouth Consumption

This figure calibrates the model's α_j and m_j to their averages in the 1960s and 2010s, respectively, while modestly raising the quarterly depreciation rate from .03 to .0375, illustrating that this mutes the effects of monetary policy considerably; the on-impact consumption response in the 2010s economy is 26% smaller than in the 1960s economy.

A Appendix

A.1 Additional Figures

Figure A.1: Compositional Shifts among Investment Components, 1960-2020

Figure A.2: The cumulative effect of a 1% hike in the Federal Funds Rate on Real Industrial Production (top row) and Real Gross Private Domestic Fixed Investment (bottom row) estimated over sample periods before and after 1983. “Time” is the number of periods after the shock, either in months (top row) or quarters (bottom row) depending on the frequency of the underlying data. We use the Wieland and Yang extension of the Romer and Romer shocks in columns one and two, and consider a robustness check using the high frequency shocks in [Nakamura and Steinsson \(2018\)](#) when they are available in the third column. One and two standard error bands are plotted, calculated as in [Romer and Romer \(2004\)](#).

A.2 Calculation of Domestic Labor Content

The computation of the domestic labor content begins with the make and use tables. Using the row-by-column convention, the use table is a commodity-by-industry table, where each column states the quantities of commodity intermediates used in a given industry's production. The make table is an industry-by-commodity table, where each column shows how the production of a commodity is distributed across industries. Dividing each column of the use table by industry gross output gives the $N \times N$ direct proportions matrix B , where N is both the number of industries and commodity types. Dividing each column in the make table the sum of each column gives the $N \times N$ make-shares matrix W . Defining $\mathbb{B} = BW$, which creates a commodity-by-commodity matrix, we compute the commodity-by-commodity Leontief inverse $(I - \mathbb{B})^{-1}$. Multiplying the Leontief inverse on a column vector of commodity demand for final use ε , the term $(I - \mathbb{B})^{-1}\varepsilon$ gives the vector of values the gross commodity output demanded to produce ε commodities for final delivery.

To account for imports, we compute the “total domestic requirements matrix” as defined by the BEA. This requires two steps in addition to the process outlined above to account for imports. First, the BEA provides total quantities of imports for each commodity type. This allows us to calculate an “import ratio” γ_j for each commodity type j , which is the fraction of imports over total domestic supply. Then, because the BEA does not have the data sources to identify how commodities are used across industries as intermediates and as final purchases, we assume imports represent a constant fraction of any use of commodity j . Then, before taking the Leontief inverse, we multiply each element of the row of the direct proportions matrix corresponding to commodity j by $1 - \gamma_j$. Then when computing the total commodity demands, each element of demand vector ε is also multiplied by the corresponding value of $1 - \gamma_j$. Taking the commodity “computers” as an example, imported computers are sometimes used as final purchases (e.g. consumption or investment) and sometimes used as an intermediate good in the production of other commodities.

Let θ_k^L be the industry k 's labor share of gross output and let $\bar{\theta}^L$ be a row vector of the industry labor shares of gross output. Let ε^i be the column vector of commodity demand shares for final use i , where an element ε_j^i expresses the domestic expenditure demanded of commodity j by a dollar of demand for final use i , $\sum_j \varepsilon_j^i = 1$. Let γ be the vector of import ratios of commodities, with $D(\gamma)$ have the elements of γ on the diagonal with off-diagonal elements equaling 0. Then the domestic labor content is measured as $dlc^i = W(I - \mathbb{B})^{-1}D(\gamma)\varepsilon^i\bar{\theta}^L$, which is a scalar. From section 3.4, $W(I - \mathbb{B})^{-1}D(\gamma)\varepsilon^i$ is a vector where the elements are the quantities of industry gross output demanded ω_{ik} .

We can also compute the share of each dollar spent on final use i paid domestically, which is the domestic share of expenditure. Let θ_k^v be the value added per gross output of industry k . Then let $\bar{\theta}^v$ be a row vector, of which θ_k^v is the k^{th} element. Then, the share of domestic expenditure $1 - m^i$ is equal to total domestic value added per dollar of final expenditure, computed as $(1 - m^i) = W(I - \mathbb{B})^{-1}D(\gamma)\varepsilon^i\bar{\theta}^v$. Lastly, we can back out the labor share of domestic production $(1 - \alpha^i) = dlc^i/(1 - m^i) = (\text{domestic labor content})/(\text{domestic share of expenditure})$.

A.3 Other Considerations

Fixed Costs and Mark-ups When estimating the domestic labor content, we also hypothesized that rising mark-ups may decrease the *marginal* domestic labor content - the amount of labor income generated by a marginal purchase of final demand component i . We used industry level estimates of fixed costs and mark-ups from [De Ridder \(2019\)](#), allowing marginal sales to not all be allocated to marginal factor payments and instead to non-labor profit. While the inclusion of fixed costs and markups lowers the level of our measure of the domestic labor content, it minimally affects the change over time.

Re-imports One concern in using the input-output tables is the potential for domestic import demand to generate demand for US exports through global input-output linkages. For example, if demand for autos increases and the cars are primarily manufactured in Mexico but parts are supplied from the US, this may increase demand for labor in parts-supplying industries. However, using world I-O tables from the World I-O Database, we find trivial effects of reimports on our estimates of the domestic labor income generated.

A.4 Decomposition of Hand-to-Mouth Consumption

First, consider log linearizing the definition of the real wage bill,

$$W_t N_t = W_t N_t^x + W_t N_t^i + W_t N_t^c,$$

around a steady state in which φ is chosen to normalize steady state $N = 1$,

$$\widehat{W_t N_t} = N^x \widehat{W_t N_t^x} + N^i \widehat{W_t N_t^i} + N^c \widehat{W_t N_t^c}$$

and using the fact that the wage bill is proportional to output in each sector:

$$\widehat{W_t N_t} = N^x \left(\frac{\widehat{P_t^x X_t}}{\widehat{P_t^c}} \right) + N^i \left(\frac{\widehat{P_t^k I_t}}{\widehat{P_t^c}} \right) + (1 - N^x - N^i) \widehat{C_t}$$

Finally, note that $\widehat{C_t}$ can be decomposed into Ricardian and hand-to-mouth consumption: working from the definition in equation (1), log linearize

$$\widehat{C_t} = \frac{\chi W N}{C} \widehat{W_t N_t} + \left(1 - \frac{\chi W N}{C} \right) \widehat{C_{r,t}}$$

Note that in our model, we have $\chi W N / C = \chi(1 - \alpha_c)(1 - m_c) / N^c$. Rewriting and eliminating the aggregate wage bill with $\widehat{W_t N_t} = \widehat{C_{k,t}}$:

$$\underbrace{\widehat{C_{k,t}}}_{\text{Hand-to-Mouth Consumption}} = \frac{N^x}{\Omega} \underbrace{\left(\frac{\widehat{P_t^x X_t}}{\widehat{P_t^c}} \right)}_{\text{Real Exports}} + \frac{N^i}{\Omega} \underbrace{\left(\frac{\widehat{P_t^k I_t}}{\widehat{P_t^c}} \right)}_{\text{Real Investment}} + \left(1 - \frac{N^x}{\Omega} - \frac{N^i}{\Omega} \right) \underbrace{\widehat{C_{r,t}}}_{\text{Ricardian Consumption}}$$

where $\Omega \equiv 1 - \chi(1 - \alpha_c)(1 - m_c)$.

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